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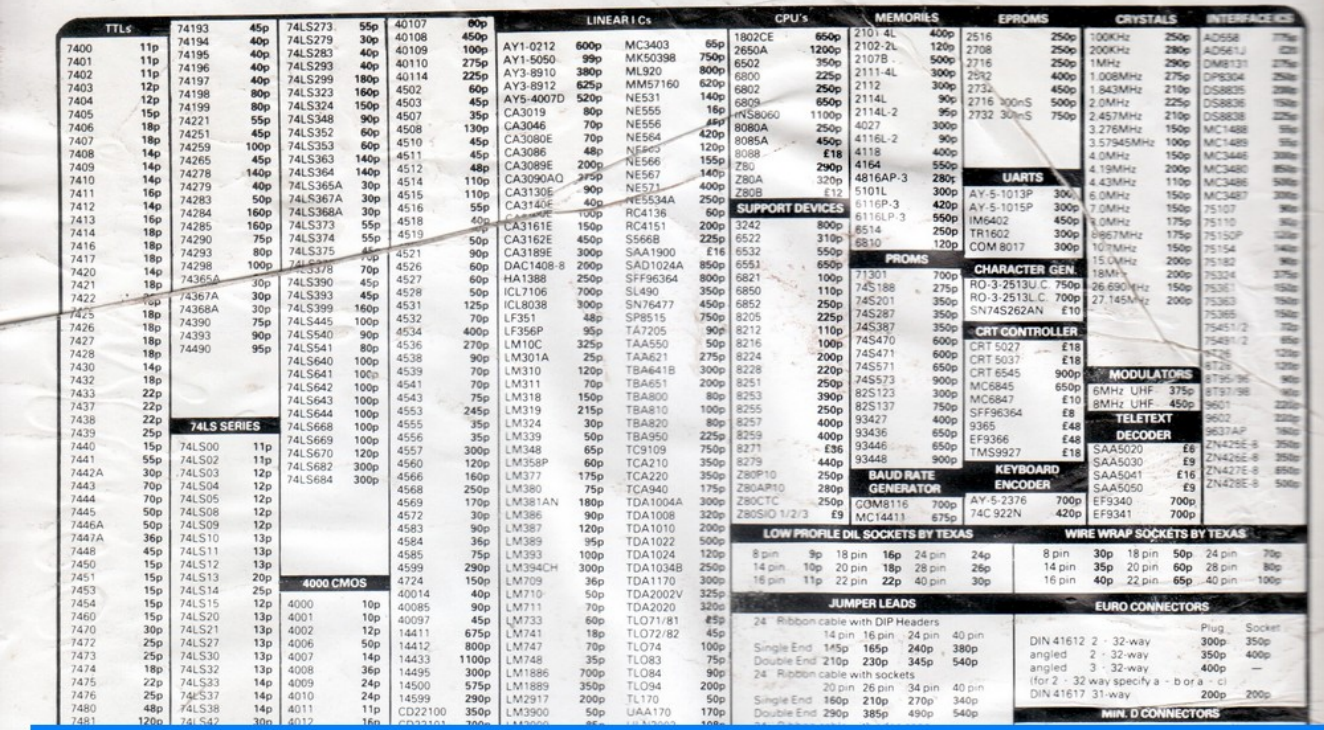

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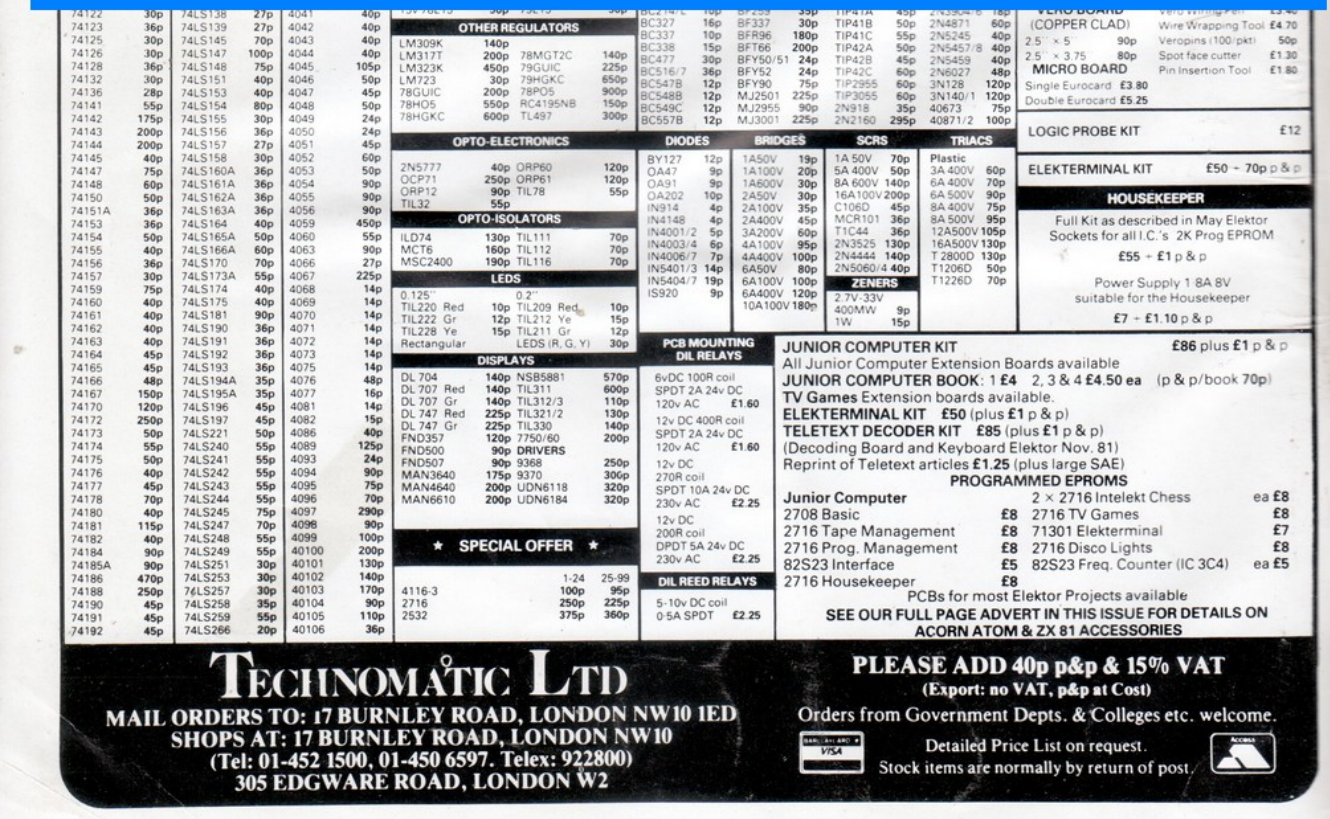

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A lab power supply is only one of the projects that will arrive with the December issue. A look at digital filters and the world of robotics will also appear together with the software for the floppy disk interface. And then there is . . . but we keep that a secret until next month.

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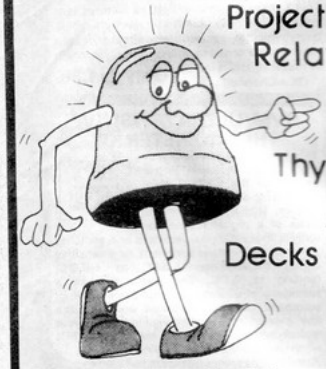

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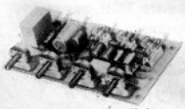

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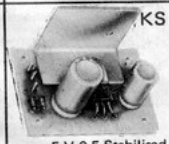

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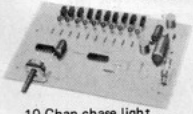

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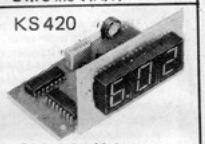

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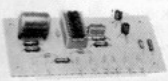

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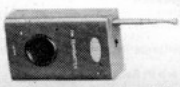

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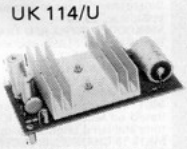

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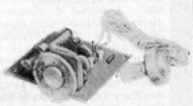

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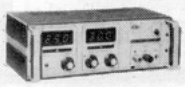

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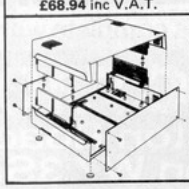

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	INCH	mm	INCH	mm	INCH	mm	
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selektor

Farming solar energy

The biggest european solar power station with a 300 kW capacity is being built on the North Sea island of Pellworm in Schleswigholstien, Germany. The station is scheduled for completion in July 1983 and will provide the energy requirements for the convalescent home that is a feature of the island. The solar panels cover an area of roughly 16000 square metres which is equal to about two football pitches. The entire project is being developed by AEG Telefunken of Germany. The generator directly converts solar energy into electrical energy. Since the plant is built on farm land, and the land is still required, the total solar array is raised about one metre above ground level allowing the area to continue to be used for sheep grazing. The three million pound project is financed primarily by the German Ministry for Technology and the E.E.C.

The entire project is being treated as an experiment and if it is successful the lessons learned will be used in the construction of further solar power stations with power outputs up to 2 MW. Long term reliability with low maintenance costs are the prime objectives being sought. The solar experts of AEG have gained considerable experience in the third world countries where energy from solar sources is extremely important.

The island of Pellworm is the site of a large convalescent centre and for this reason solar energy is well suited. Paradoxicaly, the energy requirements of the hospital is greater in the summer months than in the winter. Battery storage units are used to cater for energy use at nights and periods of poor weather. The solar farm is capable of providing more energy than is required and the surplus provides assistance to the regional grid system.

Today the cost of 1 kWh of solar energy is about £ 0.50 and AEG consider that this could be reduced by 1986-88 to about 7 p per kWh, a very considerable saving. This is not the first venture of this type that AEG have developed in Europe. Two others, both 50 kW installations, are a milk farm in Ireland and a naval college in Holland. One aim of these developments is to be sure of an energy supply to provide an export potential to areas like the third world countries. It is believed that by the year 2000 a good proportion of the worlds power will be provided by solar means.

Storage capacity of 6000 Ah

The construction of the present solar farm used standard industrial components. The solar generator itself consists of 15840 modules which are divided into 22 switchable sub groups. The solar panels are mounted at an angle of 40° by a framework consisting of zinc plated steel and tropical hardwoods. The rated output of 48 modules in series is 346 V and each subgroup of modules can be switched onto 2 d.c. busses by computer control. Each bus is connected to a battery having a storage capacity of 3000 Ah. During normal use half of the battery provides the power supply to the hospital while the other half is being charged by the solar array. When the level of the battery being charged reaches a maximum, the solar energy is diverted into the section which is in use. This is illustrated in figure 1. The graph in figure 2a shows the average sunlight levels recorded during 1972-1980 in the area.

The batteries are of sufficient size to cater for the eventuality of a number of consecutive days when the sunlight is not enough for the energy requirement. Hence 6000 Ah batteries. In the worst situation the drain would still not exceed 70% of the capacity. The battery packs are built using very high quality industrial accumulators each having a 10 hour capacity of 1500 Ah with a rated 2 V. To achieve this four groups each with 173 cells in series are needed which in effect cover an area of 1000 square metres and having a total weight of 120 tons. Although the batteries are highly efficient in order to ensure a long life span, they are treated very gingerly by the computer control and as a result maintenance is virtually zero.

Another reason for less maintenance is the use of recycling caps fitted to the top of each cell, which means no topping up with distilled water is ever necessary.

These caps contain a catalyst which cause the separated gasses (hydrogen and oxygen) to recombine to form water again, returning it to the electrolyte.

Connections to the regional grid

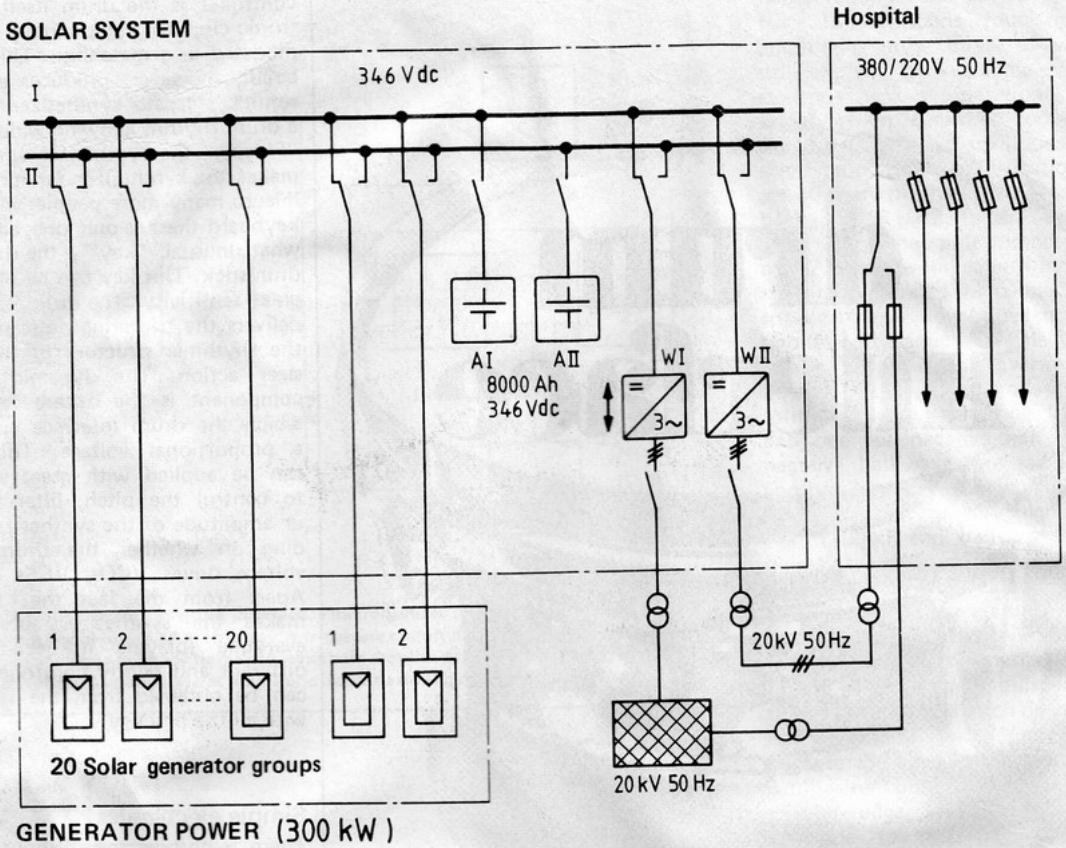
The d.c. output of the system is fed to the regional a.c. grid via a mains static converter. This converter is only operational when the solar source is connected to the mains grid. In the case of a power failure in the regional grid the solar source is inherently protected by the mains coupling. In effect if the mains source fails, the converter is automatically switched off preventing the heavy drain which would occur, therefore 'spark suppression' is also catered for in the event of deshort-circuiting. Because the converter is mains controlled the normal synchronisation problems are not encountered. The converter is designed to handle 300 kW.

Another function of this converter is to charge the batteries should a breakdown occur to the 'solar system', or if insufficient power is produced due to continual poor weather.

Inverters for the hospital

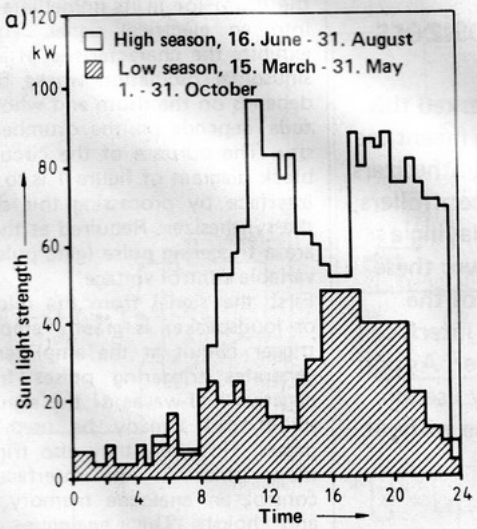
Obviously the hospital also requires an a.c. supply, therefore 2 inverters are used through which the solar d.c. supply is fed. These are rated at 75 kVA. The result is a usable 220 V 50 Hz supply. Inverters as opposed to other types of conversion are used simply because they are very efficient. At low consumption times like night time and the off peak season only 15% of the total rated power supply is normally needed, but even at these levels the inverters operate at 87% efficiency.

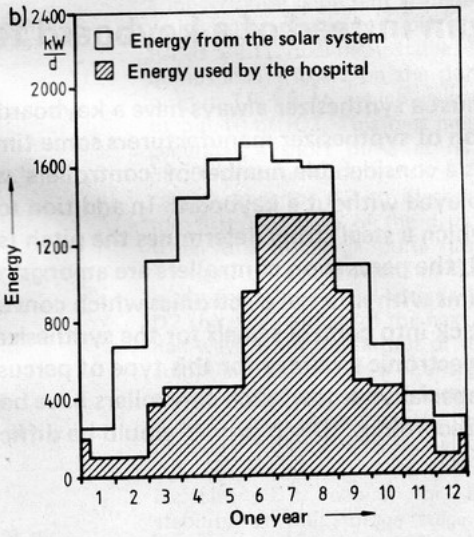
1



I: The diagram of the complete installation.
AI, AII: battery packs.
WI: the static converter.
WII: the inverter.
I and II: the solar panel arrays.

2





The facilities which are supplied by this system include a restaurant, sauna, physiotherapy installation and indoor swimming pool. The inductive load is created by several 5.4 kW motors and the resitive load by the sauna heating system which is rated at 18 kW. The control, data collecting and handling and recording centre uses a microprocessor. This is because, as the development is an experimental one, as much flexibility as possible is required. One of the targets of the program is to optimise the efficiency and therefore the economics of the complete system. The processor also controls the switching of the static converter and determines the nominal energy level which is supplied to the regional grid.
Basically this experimental development is a good way for amassing data in order to plan future systems capable of delivering power within the mega watts range.

G. Lausberg

a drum instead of a keyboard for synthesizers

Why must a synthesizer always have a keyboard? Musicians asked this question of synthesizer manufacturers some time ago. In the meantime there is a considerable number of 'controllers' which allow synthesizers to be played without a keyboard. In addition to the ribbon controllers, with which a steel string determines the pitch (similarly to playing a violon), the percussion controllers are amongst the best known: these are drums with internal electronics which convert the pulses of the drumstick into control signals for the synthesizer. The drum interface is the electronic circuitry for this type of percussion controller. As pop music specialists know, such controllers have been frequently used in recent recordings. 'Disco drums' would be difficult to imagine without this effect.

The most complicated part of a drum controller is the drum itself; the electronic circuitry could almost be accommodated in a matchbox. This compact circuit, however, produces astonishing results: staccato synthesizer sounds in a drum rhythm allowing wide variation. "Playing" the synthesizer with a drum makes the synthesizer far more accessible to many more people: instead of a keyboard there is only one, albeit somewhat unusual, "key" – the drum and a drumstick. This key can be played with great sensitivity. The drumbeat rhythm delivers the triggering pulses and hence the rhythmic structure of the synthesizer action. The dynamic (variable) component is the drumbeat intensity which the drum interface converts to a proportional voltage. This voltage can be applied with great versatility: to control the pitch, filter frequency or amplitude of the synthesizer, depending on whether the drum control voltage drives VCOs, VCFs or VCAs. Apart from the fact that the drum makes the synthesizer accessible to everyone (playing it becomes fun), different and tightly controlled sounds can be obtained from the synthesizer with a little practice.

Simple electronics

There is nothing secret about the way the drum interface operates, on the contrary it is refreshingly simple. The interface begins with a transducer in the form of a microphone or loudspeaker which converts the sound in the drum (or in its immediate vicinity) into an electrical signal. This signal exhibits the characteristic of a damped sinusoidal oscillation whose frequency depends on the drum and whose amplitude depends on the drumbeat intensity. The purpose of the circuit in the block diagram of figure 1 is to act as an interface by processing this signal for the synthesizer. Required at the output are a triggering pulse (gate pulse) and a variable control voltage.

First the signal from the microphone or loudspeaker is greatly amplified. A trigger circuit at the amplifier output generates triggering pulses from the negative half-waves of the signal; these pulses can already be used as gate pulses. However, they also trigger two monostables in the interface which control an analogue memory (sample and hold). This analogue memory accepts the maximum amplitude of the positive half-waves and holds it until the next drumbeat. Thus each drumbeat provides a triggering pulse and a new control voltage. What could be better?

The circuit

Figure 2 shows the practical implementation of the principle sketched in the

1

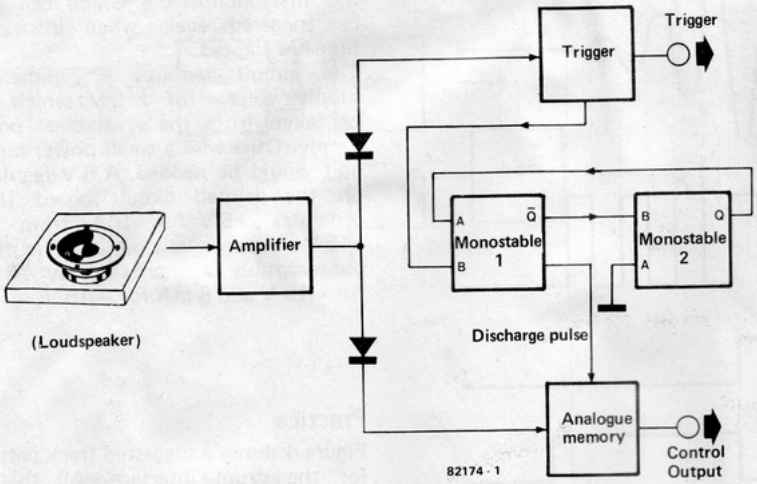


Figure 1. Block diagram of the drum interface. The transducer is a loudspeaker or microphone. From the drum signal obtained in this way, a triggering circuit delivers a trigger pulse with each drumbeat. An analogue memory holds the maximum amplitude of the signal with each beat. The result is a control voltage whose amplitude depends on the drumming intensity.

2

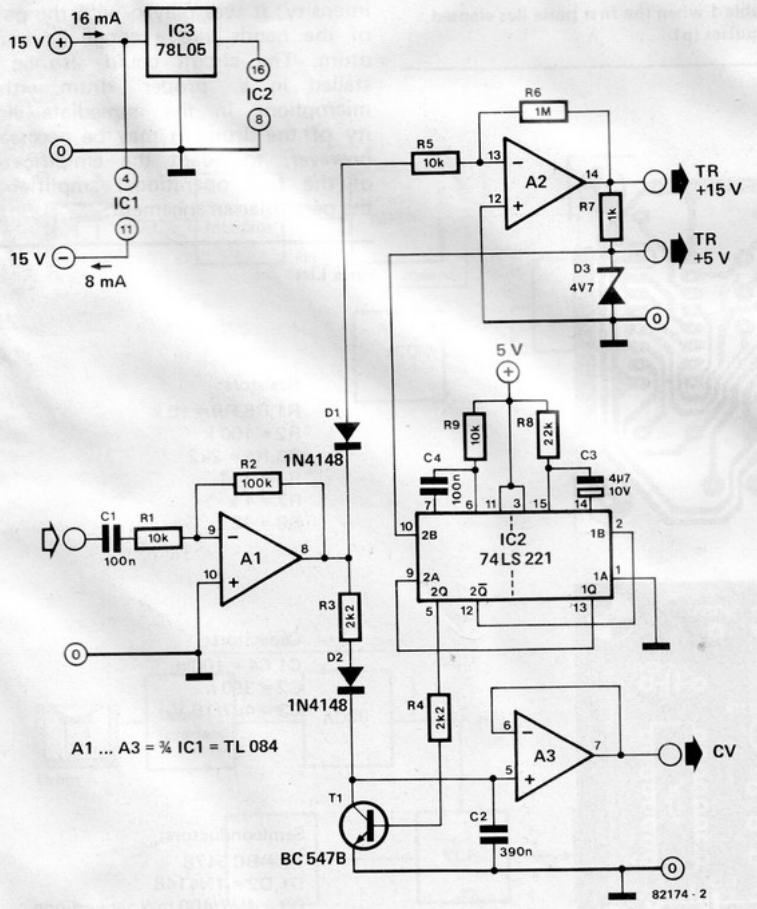


Figure 2. The circuit of the drum interface is simpler than the block diagram implies: the main components are only two low-cost ICs.

block diagram (figure 1). The components required are basically only two ICs: IC1 contains four operational amplifiers, only three of which are utilized; IC2 provides the two monostables. The first operational amplifier serves as an amplifier for the drum signal from the pick-up (loudspeaker or microphone). The amplification is fixed art 10 x, by means of the negative feedback loop R1/R2. It can be varied by using a trimmer potentiometer instead of R2. The low-impedance input of the circuit is intended for connecting loudspeakers and low-impedance microphones (dynamic or electret with integral impedance converter). At the output of A1, two diodes (D1, D2) split the signal path: one for positive and one for negative half-waves. The negative half-waves are fed via D1 to another amplifier A2, which overdrives on account of its very high amplification (100 x) and delivers square-wave pulses at its output. At output TR these pulses have an amplitude of + 15 V and at output TR their amplitude is + 5 V. Thus suitable gate levels are provided for all common synthesizers. The fact that a whole train of pulses appears at the gate output for each drumbeat does not normally cause any problem, because the envelope generators of the synthesizer only trigger on the first leading edge and then allow their envelope to develop without being affected by subsequent triggering pulses. Should there be a problem, however, the signal at pin 9 or pin 13 of IC2 can also be used as the + 5 V gate pulse. As shown in the pulse diagram of figure 3, a longer pulse is present at these points, which only appears once per drumbeat. IC2 is a TTL dual-monostable. The first monostable triggers on the pulse from output TR + 5 V, which is connected to pin 10 of IC2. This first monostable generates a short pulse at its output pin 5 which turns on transistor T1. This causes capacitor C2 to discharge with the first half-wave of the drum signal. When this discharge pulse has ended, T1 turns off again; capacitor C2 is now ready for charging and accepts cia diode D2 the peak voltage of the next positive half-wave from the output of the input amplifier. D2 prevents a discharge of the capacitor and the voltage is maintained until the next drumbeat. The high input impedance of the operational amplifier A3, which is utilized as a buffer for capacitor C2, caters for adequate stability of the storage stage. A buffered control voltage (CV) is present at the output of A3.

The second monostable with the longer pulse ensure that the first monostable only responds to the first pulse at its input with each drumbeat. This rejection of subsequent pulses is explained by the pulse diagram: the first monostable pulse is present in inverted form at pin 12. This output is connected to input pin 2 of the second monostable, which therefore triggers on the trailing

3

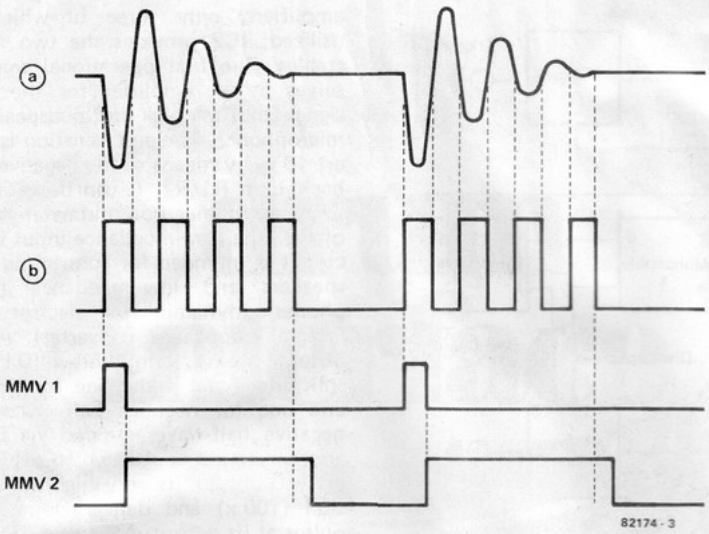


Figure 3. Signals at various points in the circuit:
a. **The drum signal, a damped sinusoidal oscillation.**
b. **Triggering pulses at the gate output. These are produced by limiting (clipping) the negative half-waves of the drum signal.**
c. **Output of monostable 1. These pulses discharge the capacitor of the storage stage before a new value is accepted.**
d. **Output of monostable 2. This pulse blocks monostable 1 when the first pulse has elapsed, in order to prevent retriggering by subsequent gate pulses (b).**

4

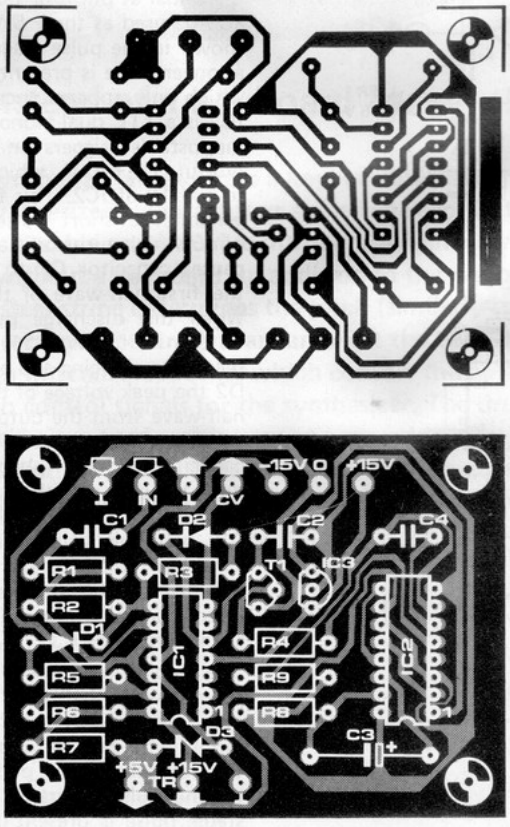


Figure 4. A suggested printed circuit design.

edge of the signal of monostable 1 and then supplies a longer pulse at output pin 13. Via pin 9, this pulse inhibits the first monostable which can only be triggered again when this pulse time has elapsed.

The circuit requires a symmetrical supply voltage of ±15 V which can be taken from the synthesizer power supply. Otherwise a small power supply unit would be needed. A 5 V regulator on the printed circuit board (IC3) generates +5 V for IC2 from the +15 V supply voltage. The current consumption is approximately 16 mA for + 15 V and 8 mA for – 15 V.

Practice

Figure 4 shows a suggested track pattern for the drum interface. All that is missing is a suitable percussion instrument. We found a very simple solution in the Elektor Laboratory: a standard, round loudspeaker of 18 cm in diameter was put to use; plastic foil was stretched over it as a drumskin. With this arrangement the output voltage at the CV output was between 1 and 5 V, depending on the drumming intensity; it was played with the palms of the hands like a conga or bongo drum. The circuit could also be installed in a "proper" drum with a microphone in the immediate vicinity of the drum. It may be necessary, however, to adapt the amplification of the first operational amplifier to the particular arrangement.

Parts List

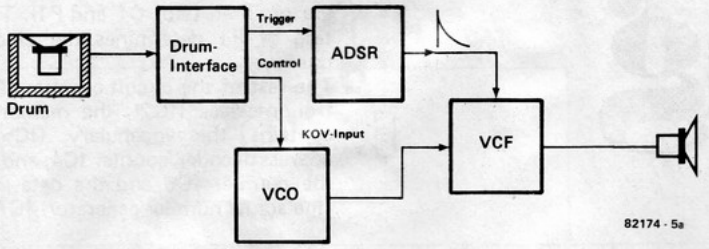
Resistors:
R1,R5,R9 = 10 k
R2 = 100 k
R3,R4 = 2k2
R6 = 1 M
R7 = 1 k
R8 = 22 k

Capacitors:
C1,C4 = 100 n
C2 = 390 n
C3 = 4µ7/10 V

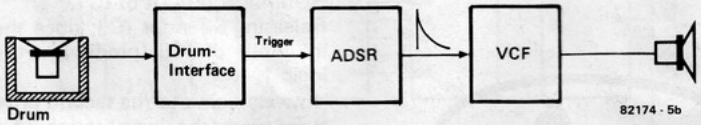
Semiconductors:
T1 = BC 547B
D1,D2 = 1N4148
D3 = 4V7/400 mW zener diode
IC1 = TL 084
IC2 = 74LS221
IC3 = 78L05

5

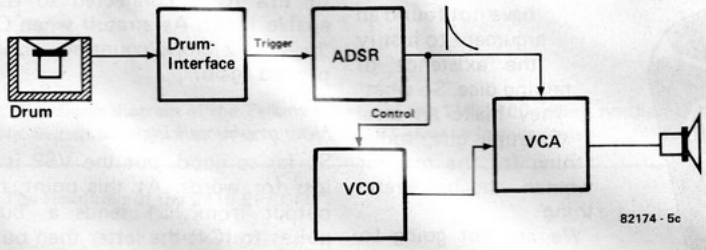
a



b



c



d

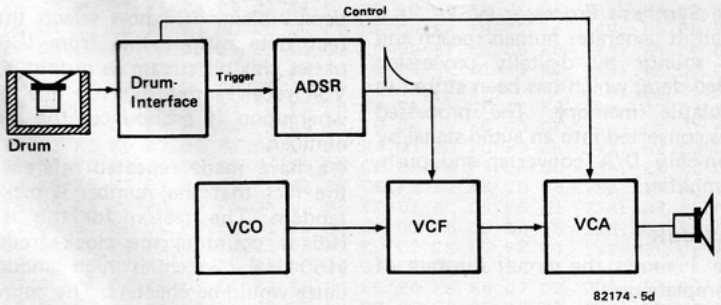


Figure 5. Examples for using of the drum interface with a (modular) synthesizer.

Methods of playing

As with a keyboard, the control signals "CV" and "gate" can be used with great versatility for producing sound with the drum interface. In the following section we would therefore like to present in diagram form some of the methods of playing that were tried out (see figure 5).

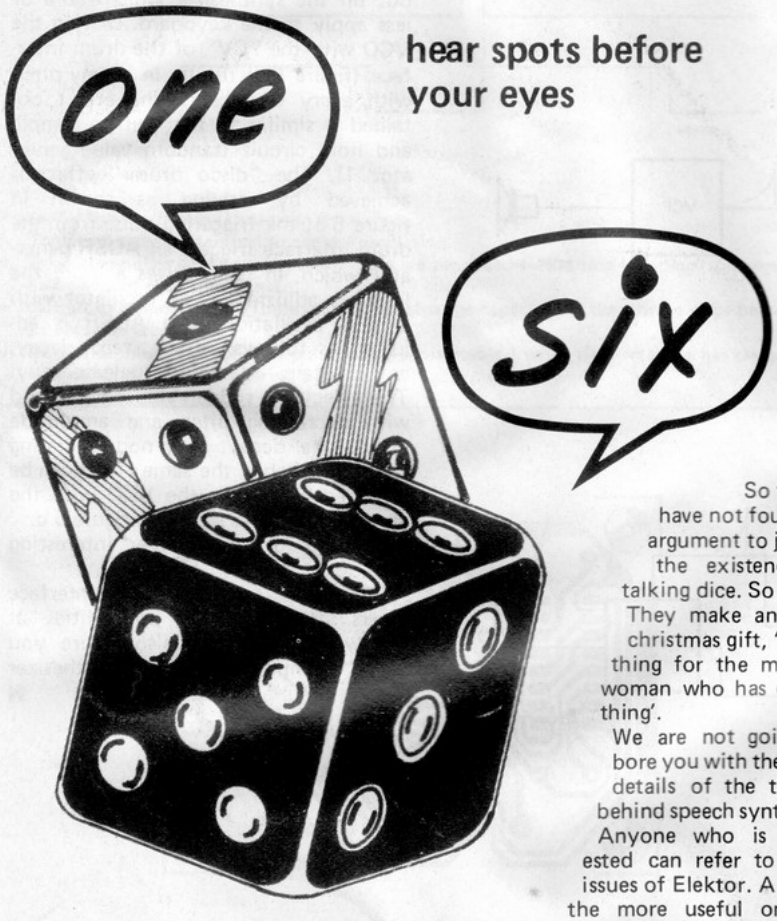
The drum interface can be connected to the synthesizer instead of the keyboard. If the synthesizer has terminals for external gate pulse and external control voltage, these can also be used; in this case the keyboard can remain connected.

With the drum interface instead of a keyboard, all adjustments can be tried out on the synthesizer which more or less apply to the keyboard. Driving the VCO with the "CV" of the drum interface (figure 5 a) results in a new pitch with every drumbeat. The effect obtained is similar to that with a sample and hold circuit (random value generator 1). The "disco drums" effect is achieved by driving as shown in figure 5 b: the triggering pulse from the drum interface triggers an ADSR generator which, in turn, drives a VCF; the latter is adjusted as an oscillator with natural oscillation. The ADSR is adjusted as follows: attack, zero; decay, any; sustain, maximum; release, any. The effect is a sudden sinusoidal sound with decreasing pitch and amplitude during the decay. If a non-oscillating VCF is available, the same effect can be obtained by driving the VCO with the envelope curve, as shown in figure 5 c.

Figure 5 d shows another interesting variation.

As one can see, the drum interface offers many creative possibilities at a low cost. We can also assure you that "drumming" with the synthesizer is a lot of fun. ◀

talking dice



hear spots before your eyes

Dice are not just old, they are positively ancient! Their origin must lie somewhere in the mists of antiquity. Roman soldiers used them; gamblers from all over the world use them; even Chancelors of the Exchequer use them. Well, at least it seems that way!
Over all this time dice have hardly changed. They are still cubes with spots. With the advent of speech synthesisers, however, the road lies open to revolutionary dice: talkers!

So far we have not found an argument to justify the existence of talking dice. So what! They make an ideal christmas gift, 'something for the man or woman who has everything'.

We are not going to bore you with the finer details of the theory behind speech synthesis. Anyone who is interested can refer to back issues of Elektor. A list of the more useful ones is given at the end of the article.

The TMS5100 is a sophisticated 'Voice Synthesis Processor (VSP)'. In a nutshell, it generates human speach and other sounds by digitally processing encoded data, which has been stored in non-volatile memory. The processed data is converted into an audio signal by the on-chip D/A converter and push-pull amplifier.

The circuit

Figure 1 shows the circuit diagram of the complete unit.

Starting with the section around the VSP: T1 and T2 form an audio amplifier. This is necessary because the internal amplifier of the IC delivers insufficient power to drive a loudspeaker. C2 acts as a ripple filter. Potentiometer P2 adjusts the volume. The TMS5100 contains an oscillator that provides the necessary clock pulses (160 kHz at pin 3 of IC1). Only three external components are required (R5, C1 and P1). The setting of P1 determines the clock frequency.

The rest of the circuit consists of a control interface (IC2); the memory that contains the vocabulary (IC5); the address decoder/counter IC4; and finally the counter IC6 and the data selector (the actual number generator) IC7.

Counting and initialisation

As a result of depressing S2 a sequence starts, as shown in figure 2a. First IC1 is initialised by pulses coming from IC2. IC2 is reset (line Q0 becomes logic 1). The pulse from S2 is inverted by T3 (logic 0) and fed to the $\overline{CI}$ input of IC6. This IC now 'selects a random number' by counting the pulses supplied by the ROM/CLK output of IC1.

Releasing S2 stops IC6, since the 'carry in' input of IC6 (pin 5) is returned to logic 1.

Now we come to the second phase. This starts with the initialisation of IC1 by the combined pulses supplied by IC2 (see figure 2a). Two PDC pulses are followed by a third, and between the second and third pulse IC4 is reset to zero. Going back to the circuit, the address counter IC4 is reset as a result of a logic 1 at pin 11 caused by a pulse from line Q5 (pin 1) of IC2. Output Q9 of this IC is connected to its clock enable input. As a result when Q9 goes 'high' IC2 stops counting, until S2 is pressed again.

Now you're talking

So far so good, but the VSP is still at loss for words. At this point, the I/O output from IC1 sends a 'burst' of pulses to IC4; the latter then outputs a series of addresses to the EPROM. This EPROM contains the data shown in table 1: all speech information for the six words in a kind of 'parallel serial' format. Line DØ gives data for the word 'one', D1 corresponds to 'two' and so on.

As described earlier, the outputs of IC6 specify the desired number. The demultiplexer IC7 now selects the correct data output line from IC5 and passes this bit stream to output X. The VSP receives this data on line ADD8, whereupon it pronounces the random number.

We have made repeated references to the fact that the number is picked at random. The reason for this is that IC6 is counting the clock frequency (160 kHz), which is high enough to deter would-be cheaters. The counter is set to count from 2 to 7, as shown in figure 2b. When output Q3 (pin 2) of IC6 goes 'high', the preset enable input (pin 1) is activated. Preset inputs P0 . . . P3 are wired in such a way that

1

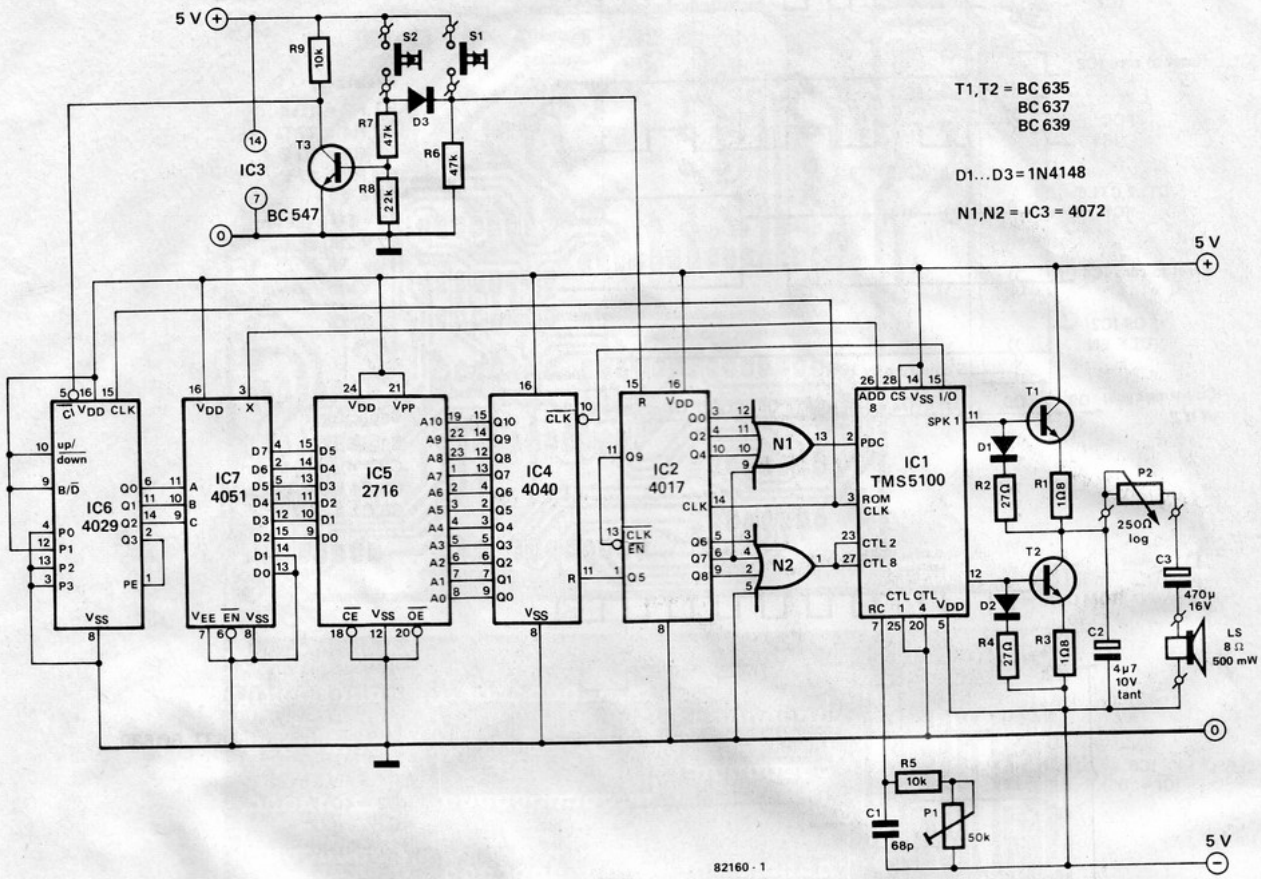


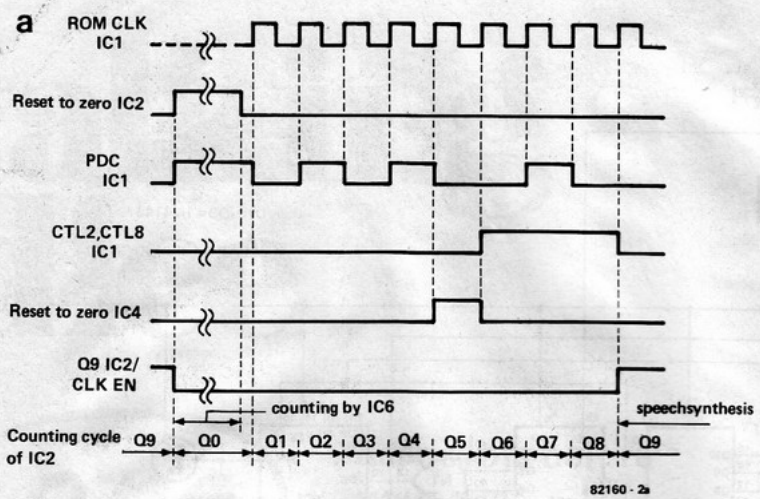
Figure 1. The circuit diagram of the Talking Dice using the TMS 5100 speech synthesiser. A ready prepared EPROM 2716 with the vocabulary is available. Switch S2 picks a random number, and S1 gives an instant replay.

Table 1. The Hexdump of the 2716 EPROM.

HEXDUMP:

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
000:	FF	C0	F3	CD	CD	C0	C1	C0	C1	C0	C0	C2	FE	F8	FD	DA
010:	C1	DF	C6	DB	C6	C1	FE	DD	D0	E9	D6	C7	F2	C0	FA	DE
020:	E7	C0	C1	C0	C1	C1	C0	E2	FC	E6	DB	FF	C0	E7	FF	C8
030:	F7	C3	DD	F6	FB	C2	FE	ED	D0	C0	FF	F0	EE	CC	C1	C0
040:	C0	C1	C1	ED	F3	FE	D5	D0	E2	DD	FD	DC	FA	C1	F6	F8
050:	DE	C1	FF	E0	FD	DA	FF	E8	D3	C0	DF	CC	C9	C4	D9	E1
060:	F6	E5	EC	E7	F8	C3	F9	CE	C1	D2	E0	EC	E1	FA	CC	D5
070:	DB	D4	EB	EB	EF	E3	DC	C7	D2	C0	DF	DD	EE	FB	C2	F6
080:	C8	D2	DD	CD	DA	D7	F6	DF	F9	C2	CF	D0	CF	CB	C6	EB
090:	E2	F6	E1	EC	D5	F8	E7	F6	EB	C3	FC	EE	EC	DC	F3	FC
0A0:	E7	F9	C0	FD	F6	DC	C0	FE	E6	F1	D2	CE	EC	FB	DD	E0
0B0:	D6	EA	F3	DC	DC	CB	E7	FC	F2	DB	E0	EA	D5	CD	ED	E2
0C0:	C0	E2	D7	C9	E4	F5	D0	FF	C6	EA	F6	D9	C2	ED	DD	DF
0D0:	EC	E3	F1	E9	F7	C2	FC	D0	E6	EF	F4	D3	ED	FC	F9	DA
0E0:	E6	C7	EE	F2	E9	D8	EE	E6	F5	DA	CF	C2	F8	F3	EA	EC
0F0:	C3	E9	F6	F2	C1	C8	F6	F1	EB	EF	CE	F2	F2	DF	CD	E8
100:	F5	DA	C1	EC	FC	C2	F5	DA	E5	F7	EF	D1	EC	C3	F6	F1
110:	C2	D4	E5	FD	C2	FD	FE	E1	E9	DB	C0	DC	F6	DD	D3	C8
120:	CC	DB	E9	F4	F2	CE	F2	C7	D0	F9	FD	C2	CE	D2	FF	CC
130:	E8	E2	FF	E8	F5	CA	CE	F3	DB	D0	E0	E9	D7	CC	F6	E1
140:	D7	CC	D7	D4	EE	DF	D5	E8	E6	D4	FB	E4	FF	F6	C7	D2
150:	EF	DC	C9	EF	F8	F1	E5	FF	C5	E3	DC	DC	C2	C5	DC	D2
160:	DC	C6	CB	DC	C3	FF	CA	CE	DE	DD	D6	CA	DD	D3	E8	F7
170:	F2	CE	DD	F7	D0	EE	DF	F0	D8	E7	E2	CD	D8	FB	E3	F2
180:	CA	FD	FE	C6	E7	C8	C1	D9	D7	D5	CE	F7	E8	E5	D6	CB
190:	CB	CD	D6	D3	F9	F7	E6	CF	EB	DA	F9	E4	DA	E4	D7	C8
1A0:	F7	EE	C3	F8	F3	C4	F9	CA	D1	CF	F1	CC	CD	DC	D7	CB
1B0:	DA	FA	F8	F3	EF	C7	CC	D5	D9	C6	D4	FE	FC	D9	C5	CF
1C0:	C3	D6	D9	C2	E7	ED	F3	F3	EA	EF	CA	EA	D7	D3	C9	F0
1D0:	FD	ED	E4	C3	CB	C4	C1	DC	FC	D5	FD	CD	CF	D1	CA	C5
1E0:	E9	FE	E2	ED	C3	D5	CE	DB	D0	D5	DF	DA	C0	C4	F1	D7
1F0:	EB	C8	D5	E9	C0	D0	C8	D0	DB	CE	C9	FB	EC	F2	F3	C0
200:	F6	D8	CB	E6	C5	CC	E3	CA	F4	C1	F6	F9	CA	C6	E5	D9
210:	D0	C5	DD	C6	CD	CB	D3	E0	F9	EA	F3	C3	F1	C8	DE	C1
220:	C7	D9	F2	CD	EF	C0	EA	E8	C0	D1	EB	EB	E4	C7	CD	CC
230:	CB	C7	DB	EF	F0	E1	CC	D7	C8	F4	E1	CA	F9	E9	C7	C6
240:	D0	E2	C9	C1	C3	D0	EB	E2	EC	C9	CE	C7	CB	C9	D4	F7
250:	E9	E0	CE	D3	F4	DA	C6	DE	C8	E1	D7	D9	E6	EC	C3	D9
260:	F0	FB	D8	CF	CB	C4	C2	CA	C9	CC	CE	EE	E7	C2	D0	E6
270:	D7	E1	FD	C2	E6	E7	C4	C6	C2	E1	C5	C6	FF	D9	FF	E9
280:	C3	E9	C5	CA	C6	C0	DE	EE	C8	F0	E8	C4	DA	E6	FF	E8
290:	D5	C0	E7	E4	C6	C2	C4	F2	FA	D0	CE	DD	E5	F6	DA	E3
2A0:	DE	C1	ED	FD	DF	C0	DB	F4	CE	C2	DF	F9	D7	E6	C1	E5
2B0:	E3	C2	C2	D4	F8	DC	EA	EB	F6	E9	FF	CD	DC	C5	F9	FE
2C0:	E9	C5	DA	F5	F9	CD	DB	F4	C8	C2	CB	E4	C5	E6	EE	F0

2



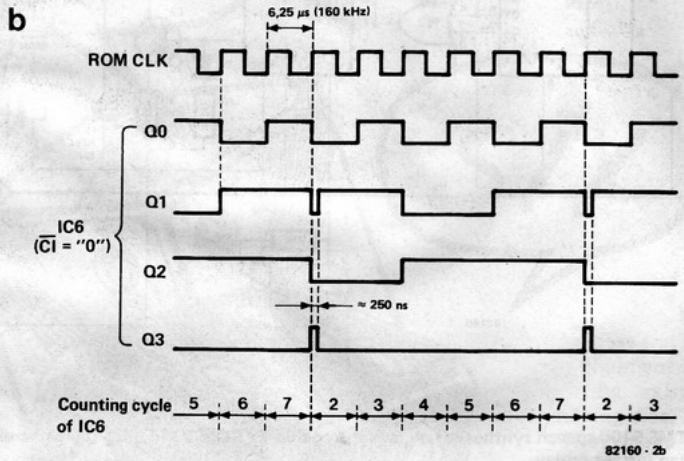


Figure 2. The various control signals, which must be applied to enable the circuit to work effectively.

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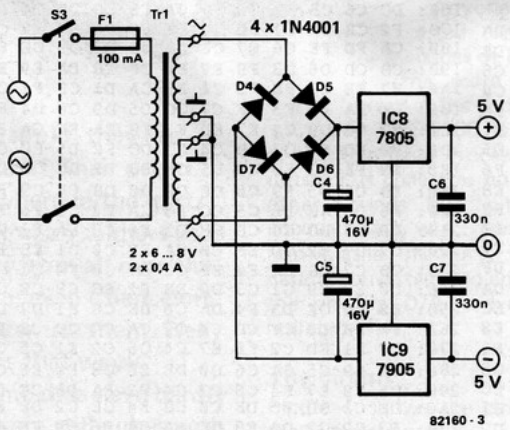


Figure 3. The circuit diagram of the power supply.

Parts list

Resistors:
R1,R3 = 1Ω8
R2,R4 = 27 Ω
R5,R9 = 10 k
R6,R7 = 47 k
R8 = 22 k
P1 = 50 k preset
P2 = 250 Ω log.

Capacitors:
C1 = 68 p
C2 = 4µ7/10 V tant.
C3,C4,C5 = 470 µ/16 V
C6,C7 = 330 n

Semiconductors:
D1 . . . D3 = 1N4148
D4 . . . D7 = 1N4001
T1,T2 = BC635, BC637, BC639
T3 = BC547
IC1 = TMS5100
IC2 = 4017
IC3 = 4072
IC4 = 4040
IC5 = 2716
IC6 = 4029
IC7 = 4051
IC8 = 7805
IC9 = 7905

Miscellaneous:
S1,S2 = pressbuttons
S3 = 2 pole - 2 way
F1 = 100 mA slow-blow fuse
Tr1 = transformer 2 x 6 . . . 8 V/2 x 0,4 A
loudspeaker 8 ohm/0.5 W

the counter always returns to the number two. This method using a synchronous counter, ensures that all numbers have an identical (one in six) chance of occuring.

Say that again!

If in the heat of the moment (while playing), someone does not hear the answer from the dice, simply depress S1 and the number just 'thrown' will be repeated. In effect, S1 does the same job as S2, as far as IC2 and the speech synthesiser are concerned. However, D3 prevents it from enabling T3, so the

4

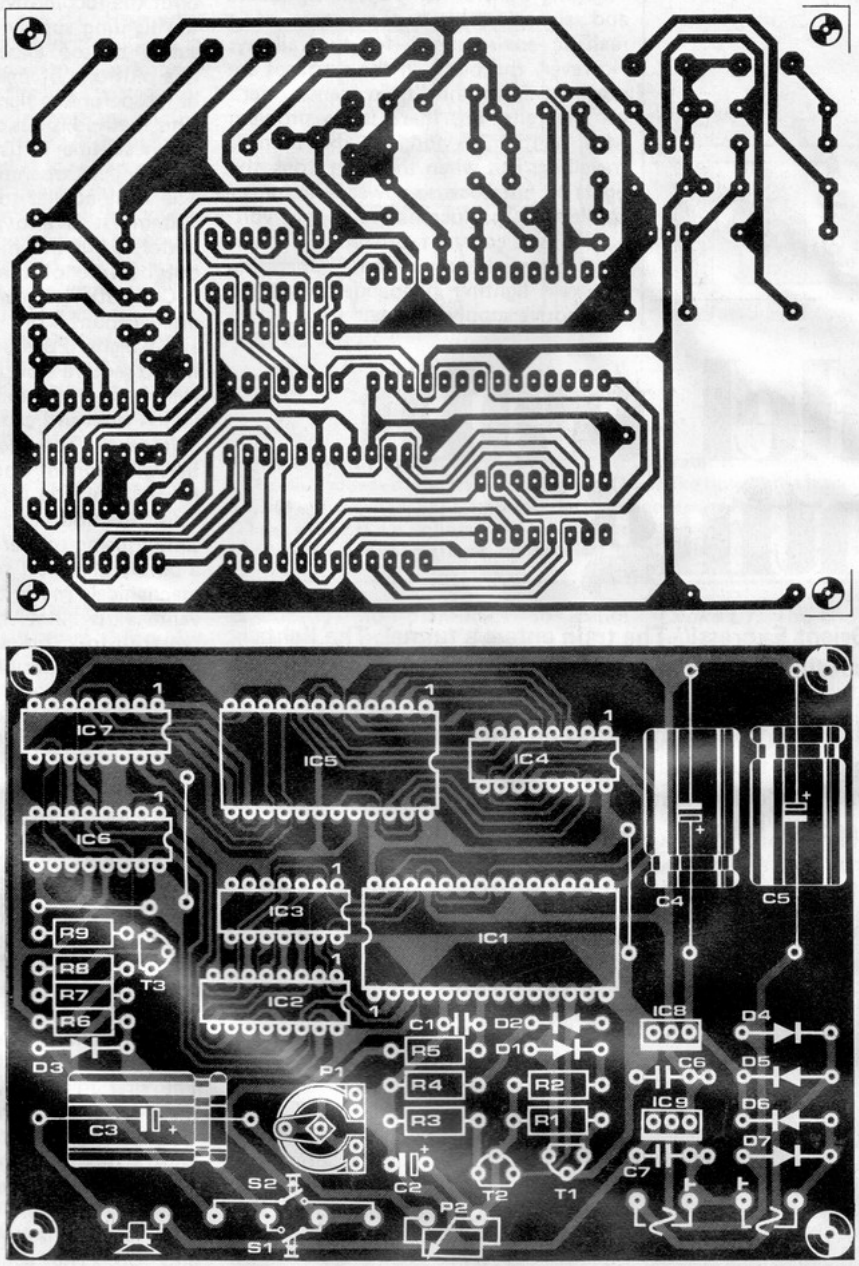


Figure 4. The printed circuit board for the talking dice and the power supply, as shown in figures1 and 3.

counter (IC6) remains in its current position.

Power supply

Figure 3 shows the power supply, using a normal three-pin voltage regulator. The CMOS ICs and the EPROM only require a positive 5 V supply, but the TMS5100 needs a negative supply as well.

Construction and calibration

Figure 4 shows the printed circuit board for the complete circuit. No provision has been made for mounting the transformer, switches S1 . . . S2 and the volume control. We suggest that constructors start with mounting the power supply components, checking that the voltages and polarities are correct before going further. If you use a transformer with two secondaries, ensure they are connected the correct way round.

Calibration is a straightforward case of simply adjusting P1 (the clock frequency) until the pitch of the voice sounds human. Alternatively, you can have a 'donald duck' sound if you prefer.

To make life easier a loaded EPROM is available from Technomatic Ltd (see their advertisement).

One suggestion put forward for a suitable case is to construct a cube from perspex.

As the saying goes 'the die is cast'.

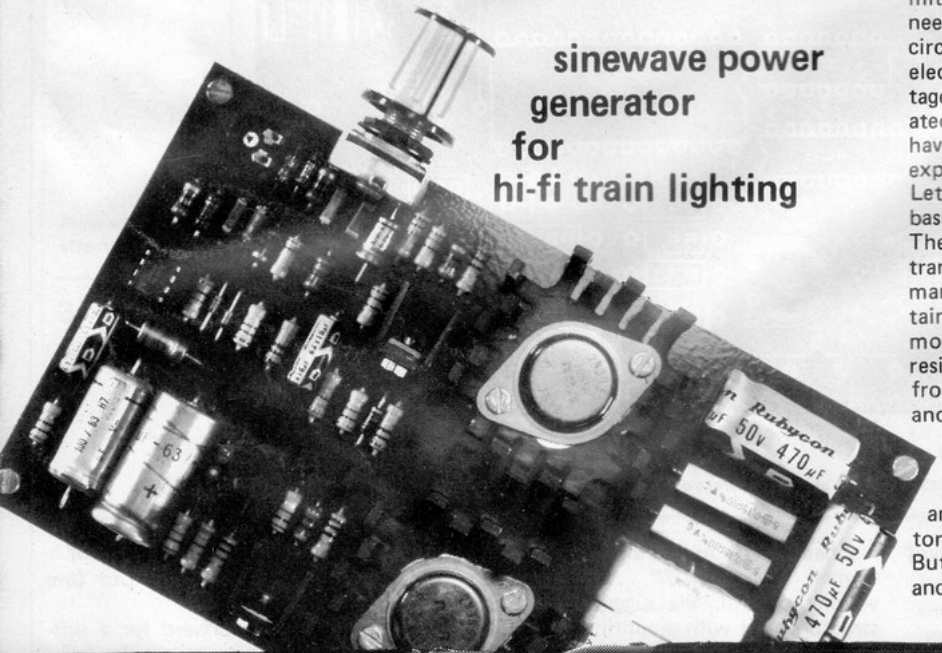
Useful back issues for the theory of speech synthesis.
September 1981 Talking chips.
December 1981 Talking board.
February 1982 Talking board interface.

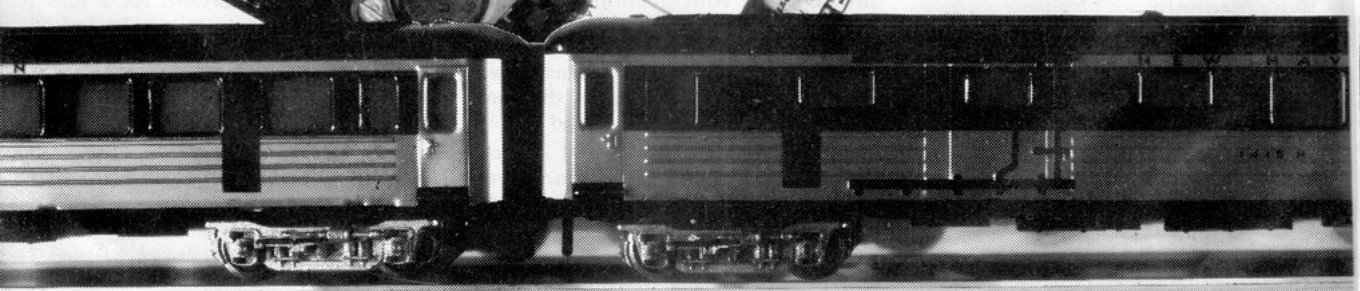
What is actually involved? Well, the lighting for the railway itself can be provided quite simply by means of a "lighting transformer". Stations, houses and signals then become part of a realistic environment, for the railway. However, the bulbs in the carriages are powered from the "train transformer" via the rails. So, there is no problem with lighting as long as the train is travelling. But when the train stops, the lights go out because power is no longer applied. If the locomotive supply voltage is not constant the bulbs flicker. What we need is a method of operating the train lighting independently of the locomotive supply voltage.

model train lighting

"Murder on the Orient Express!" The train enters a tunnel. The lights go out. A blood-curdling scream is heard and the famous detective Hercule Poirot has another assignment. Things are not usually so dramatic amongst model train enthusiasts and one cannot normally look into the tunnel of a model railway. But when the train stops and the internal lighting goes off, it is not very realistic. What we need is a circuit that will keep the lights on, even when the train stops.

sinewave power generator for hi-fi train lighting





A look at various solutions

One could, for example, construct a multiple rail system which would carry both the locomotive supply voltage and the lighting supply voltage; that would surely be too expensive. An overhead line plus one of the two rails could also be used for the lighting supply voltage. This method is less complicated, but the overhead line is usually employed for independent operation with two trains. The same applies to any third rail in the system. It is also possible to use dry batteries but this method must be ruled out because of the cost. Rechargeable NiCd batteries cannot be employed on account of their price, shape and weight. Furthermore, that method would require a bridge rectifier.

Half-wave operation is worth considering. A sinewave can be divided into two half-waves. The motor is activated for the duration of one half-wave and the lighting for the duration of the other. This method can be applied quite simply using properly rated diodes. It is a purely electrical solution without any mechanical modifications. The disadvantage is that half-wave operation requires four times the power output for normal operation. Moreover, this method only works for one direction of travel although it is possible to operate two trains independently in this way.

Our solution

A sinewave power generator. Admittedly, it is not new but no changes need to be made to the railway and the circuit can be constructed with simple electronic components. These are advantages that will particularly be appreciated by model constructors who have not had too much electronic experience.

Let us examine the situation on the basis of the block diagram in figure 1. The first item we notice is the "train transformer". We have used quotation marks because this transformer also contains a rectifier. This block powers the motor. The choke represents a negligible resistance for d.c. The bulbs are isolated from the d.c. supply by capacitors C2 and C3. The generator supplies the lighting voltage for the bulbs instead.

The a.c. voltage is applied via blocking capacitor C1 to the tracks and from there to the bulbs via capacitors C2 and C3.

But what is the purpose of the choke and the capacitors? The choke presents

the a.c. voltage with a very high impedance so that the sinusoidal power is not lost in the low-impedance secondary side of the train transformer. Blocking capacitor C1 isolates the d.c. train voltage from the power generator. Only in this way is it possible to superimpose the a.c. voltage on the d.c. voltage for our purposes. One disadvantage should be pointed out, however. Although the motor represents a load for the a.c. voltage it is so small it can be discounted. Two questions that might be raised with respect to the power generator are: why a sinewave and why 20 kHz? Wouldn't a square-wave generator be much more efficient? The answer is yes, but the harmonics would cause severe interference to other equipment! We have chosen 20 kHz because the circuit and the locomotives start buzzing at lower frequencies and because this frequency allowed us to choose smaller values for the choke and capacitors. But we will go into this in more detail later.

1

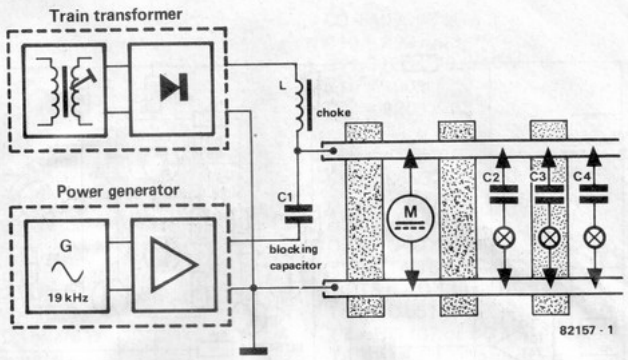


Figure 1. The a.c. output voltage of the power generator is applied to the tracks, superimposed on the a.c. voltage of the train transformer. The choke isolates the train transformer from the a.c. voltage and capacitor C1 isolates the power generator from the d.c. voltage. Capacitors C2, C3 etc. keep the d.c. voltage away from the bulb circuits. Apart from having to install the bulbs and capacitors in the carriages, no technical modification to the railway system is necessary.

The power generator

Before the system can be extended as shown in figure 1, we must first build the power generator and ensure that it is operating. First we shall have a look at the circuit.

Figure 2 mainly contains two functional parts: the sinewave generator using IC1 and the output stage consisting of T1 . . . T10. Choke L1 can also be seen, together with the power supply unit for the power generator with transformer, rectifier B1, and smoothing capacitor C14. A no-load d.c. voltage of 42 . . . 51 V is present at C14, depending on the transformer used.

The sinewave generator is configured as a Wien-bridge oscillator with IC1, D1, D2, C1, C2 forming a symmetrical power supply for the operational amplifier from the "asymmetric" operating voltage. This method also provides decoupling from the operating voltage of the output stage. R2, C3, C4, R5 are the generator components that determine the frequency. The oscillator frequency obtained purely by calculation is 19 kHz. The two germanium diodes provide coarse stabilisation of the output voltage. The gain (onset of oscillation) is adjusted with P1, and P2 is used to attenuate the amplitude of the generator (bulb brightness). The distortion factor of the sinewave oscillator is only 0.05%. It therefore emits practically no harmonics to cause distortion in the power generator.

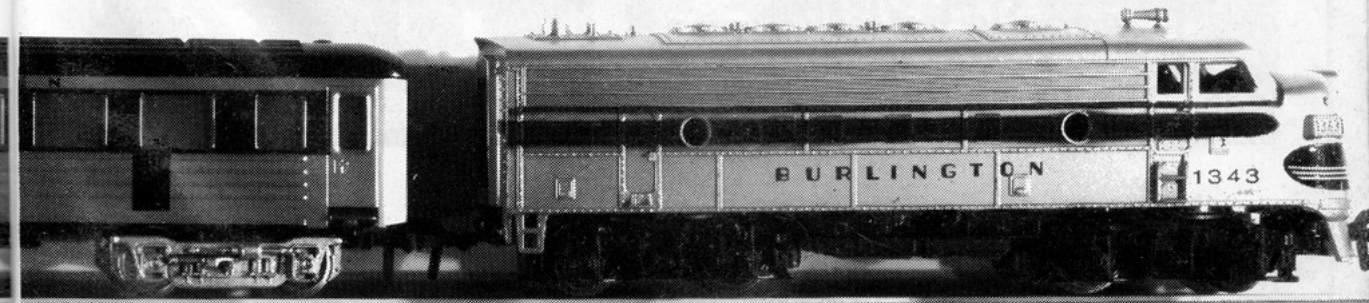
The next item is an old friend (as far as Elektor staff are concerned): EDWIN the output amplifier. This was first published way back in the seventies. In the meantime it has probably become the favourite and mostbuilt amplifier from the Elektor Laboratory. It is characterised by good reproducibility in construction, requires no alignment and the output transistors can now be procured at very low cost in most electronic component shops. The values of a few capacitors were reduced from those of the original circuit, because the amplifier is only needed to provide gain at 19 kHz. The output capacitor must be a bipolar type. Two polar electrolytic capacitors were connected back-to-back here. The output stage is shortcircuit-proof but not in continuous duty! We also thought that the finger-type heatsinks would be very practical for circuit constructors and they are quite adequate in this application. We shall discuss the assembly in more detail later.

Choosing the components

Before you pick up your soldering iron, here are a few useful comments concerning the components.

Choke L1: The choke must withstand a bulb current of about 2 A. With a total bulb power rating of 25 W maximum at 12 V the load current is 2 A. Suitable (mains) chokes must exhibit an inductance of 10 . . . 20 mH. The d.c. resistance at a frequency of 19 kHz is 1k2 . . . 2k4. The choke with its impedance of 3 . . . 6 ohms is practically a shortcircuit for mains frequency voltages. A mains choke from an old TV set is just as good as one of the new commercially available types. Coils from loudspeaker cross-over networks may also be employed if they meet the requirements.

Mains transformer: Using a transformer with a secondary voltage of 33 V, the output stage delivers about 25 W (at Urms = 12 V). This is where term hi-fi the scene. Hi-fi means "high fidelity" and here we are referring to realistic lighting in the train. The lighting voltage is adjusted so that the bulbs are operated at less than their rated voltages. In this way we achieve two things: the bulbs are not unrealistically bright (in keeping with our "hi-fi") and they last much longer than their rated service lives. For example, 14 V bulbs can be connected to the 12 Vrms output voltage or a 30 V transformer could be used to give an output voltage of 10 . . . 11 Vrms.



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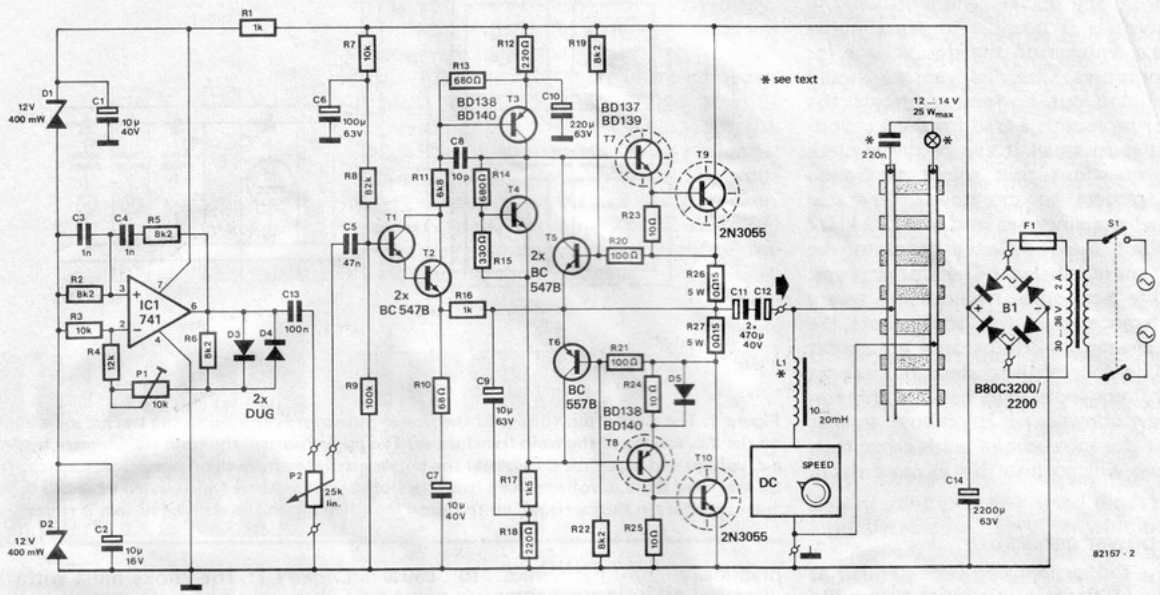


Figure 2. The circuit of the sinewave power generator consists of a Wien-bridge oscillator with IC1. Brightness of the train lighting is continuously variable with P2. The output capacitor must be a bipolar type because the rail voltage can be positive or negative (with respect to earth), depending on the direction of the travel.

3

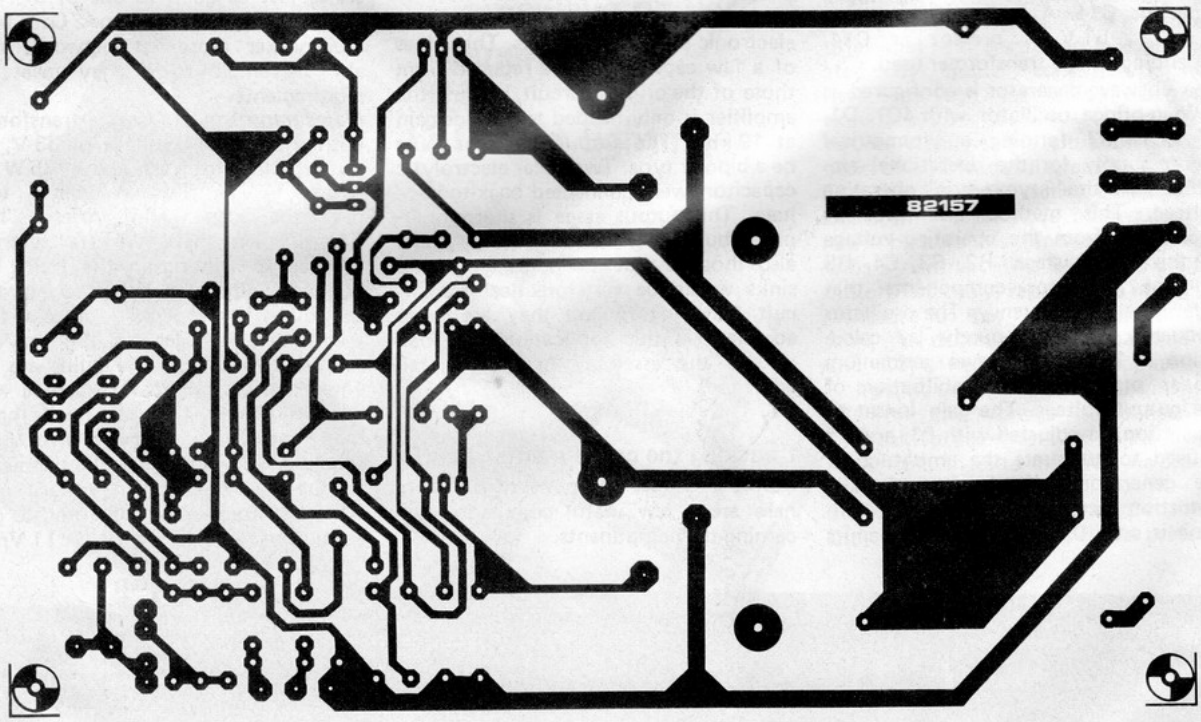


Figure 3. The printed circuit board for the power generator. All components are mounted on the board except for the mains transformer, fuse and mains switch. Since the output transistors are mounted on the printed circuit board with heatsinks (see text), the cover of the housing must allow sufficient ventilation.

In any case, the full output power of 25 W will never be required from the output stage. That would be sufficient to illuminate 25 carriages! The maximum output voltage will therefore be somewhat higher than indicated, on account of the lower load. Since the bulbs are operated at less than their rated voltage, their full power ratings are not reached either. This means that bulbs with a total power rating of more than 25 W can be connected.

Blocking capacitors: The capacitors in series with the bulbs are installed in the carriage together with the bulbs. A 220 nF capacitor is sufficient for a 12 V/50 mA bulb. If only one capacitor is connected in series with several bulbs of this type, its value must be increased proportionally. The exact voltage being dropped over a capacitor is not particularly critical, because the bulbs are being operated at less than their rated voltages. However, it is possible to arrange for "emergency lighting" in a sleeping car, for example, by selecting an appropriate value for the blocking capacitor. Those who would like to experiment can calculate the required series reactance according to the formula $X_C = \frac{1}{2 \cdot \pi \cdot f \cdot C}$. X_C should be at least 80% less than the bulb resistance (e.g. 240 Ω at 12 V/50 mA).

Parts list

Resistors:
R1,R16 = 1 k
R2,R5,R6,R19,R22 = 8k2
R3,R7 = 10 k
R4 = 12 k
R8 = 82 k
R9 = 100 k
R10 = 68 Ω
R11 = 6k8
R12,R18 = 220 Ω
R13,R14 = 680 Ω
R15 = 330 Ω
R17 = 1k5
R20,R21 = 100 Ω
R23 . . . R25 = 10 Ω
R26,R27 = 0,15 Ω/5 W
P1 = 10 k trimmer
P2 = 25 k lin. pot.

Capacitors:
C1,C7 = 10 µ/40 V
C2 = 10 µ/16 V
C3,C4 = 1 n
C5 = 47 n
C6 = 100 µ/63 V
C8 = 10 p
C9 = 10 µ/63 V
C10 = 220 µ/63 V
C11,C12 = 470 µ/40 V
C13 = 100 n
C14 = 2200 µ/63 V

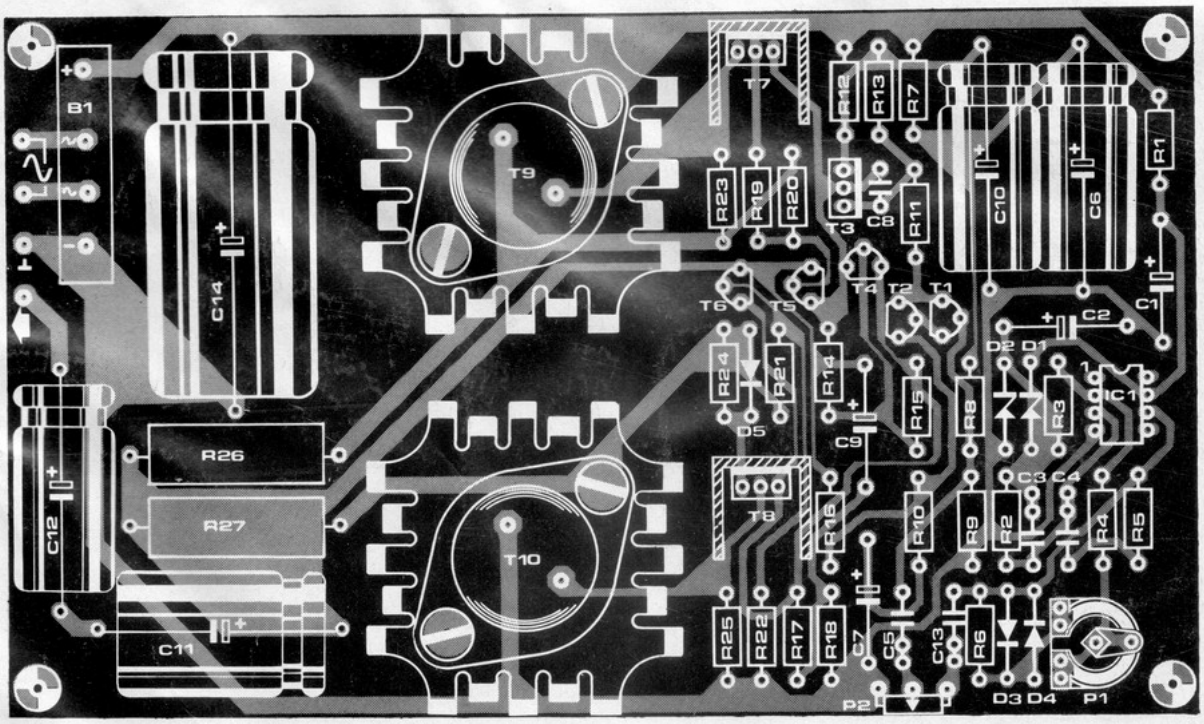
Semiconductors:
B1 = B80C3200/2200
D1,D2 = Z-Diode 12 V/0,4 W
D3,D4 = AA 119
D5 = 1N4001
T1,T2,T4,T5 = BC 547B
T3,T8 = BD 138 or BD 140
T6 = BC 557B
T7 = BD 137 or BD 139
T9,T10 = 2N3055
IC1 = 741

Miscellaneous:
L1 = (mains) choke 10 . . . 20 mH (see text)
Tr1 = mains transformer 30 . . . 36 V/2 A sec. (see text)
F1 = 2 A fuse, slow-blow with holder
S1 = double-pole mains switch

Construction and alignment

Construction of the sinewave power generator should present no problem using the ready made printed circuit board (figure 3).

T7 . . . T10 are fitted with heatsinks. In the case of T7 and T8 they are bracket-type heatsinks which are simply installed on the cooling surfaces of the transistors with M3 bolts. Do not forget the heat-conducting paste and ensure that there is no contact with any bare



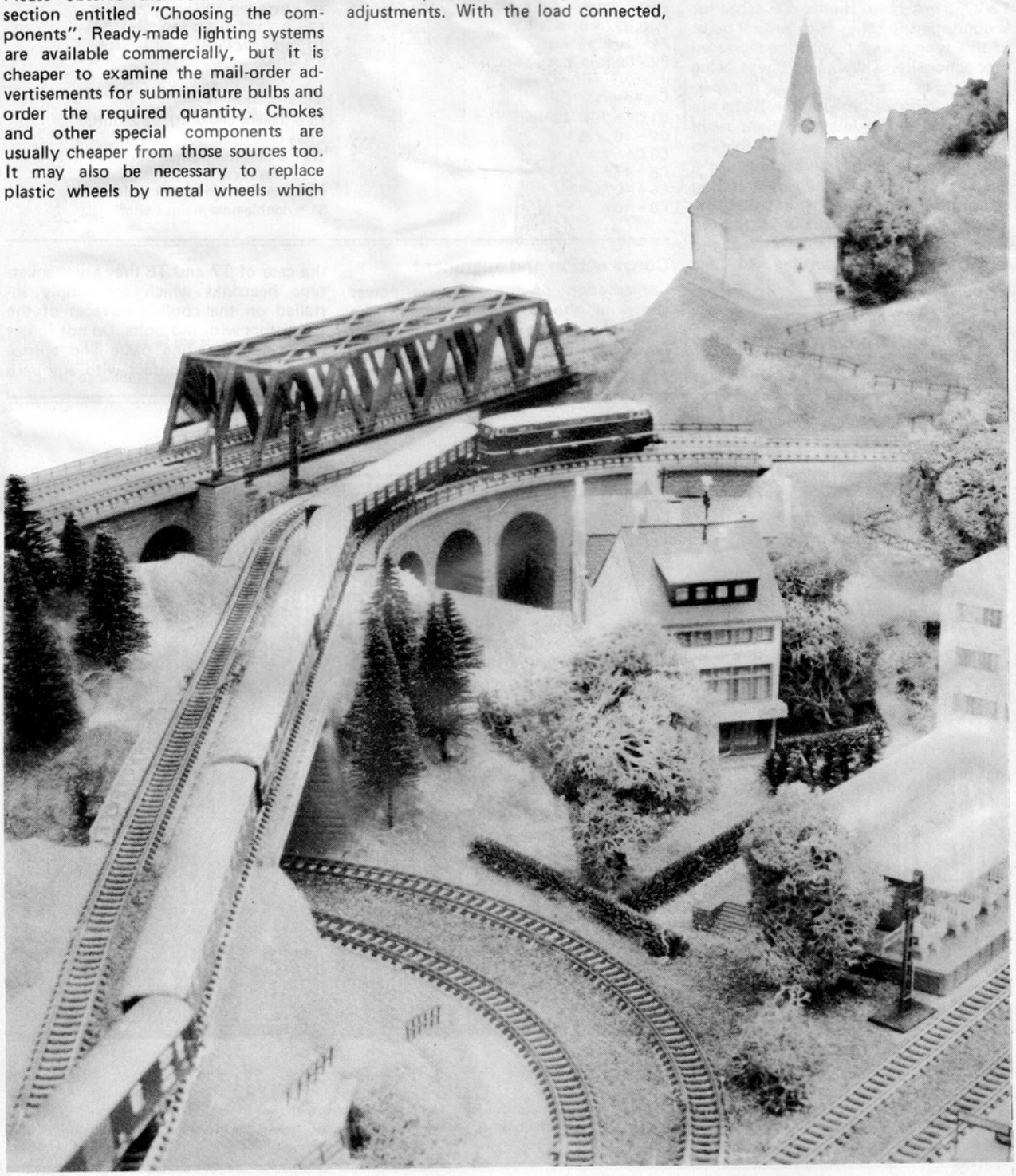
wires. T9 and T10 are fitted on the printed circuit board together with heatsinks. Sleeving should be slipped over their pins to prevent any short-circuits. The contact surfaces for the collectors are first tinned on the soldering side. The transistors and heatsinks are then bolted to the printed circuit board. Use washers to keep them firmly in place. Remember the heat-conducting paste here too! Finally, the insulated terminals are soldered to the tracks.

Once the components have been fitted to the printed circuit board, the system can be expanded as shown by figure 1. Please observe the comments in the section entitled "Choosing the components". Ready-made lighting systems are available commercially, but it is cheaper to examine the mail-order advertisements for subminiature bulbs and order the required quantity. Chokes and other special components are usually cheaper from those sources too. It may also be necessary to replace plastic wheels by metal wheels which are mounted on the axles in an insulated manner. Your local model shop can advise you on this.

Once the circuit is completed in accordance with figures 1 and 2, switch S1 can be actuated for the first time with the hope that there will be no smell or smoke! Set P2 to maximum output and adjust P1 so that the bulbs are lit. The output voltage can be measured with a multimeter set to the a.c. range. It must not exceed 12 V. The setting can also be made by eye: rotate P1 so that the bulbs light up at the desired brightness. Those model constructors who own an oscilloscope can make "professional" adjustments. With the load connected, P1 is set to a point just before the "clipping" of the displayed sinewave, (with no limiting of the amplifier). Brightness of the bulbs can now be adjusted as desired with P2.

Another important comment: In this form the circuit is only suitable for d.c.-driven trains. A combination with pulse-controlled systems is possible.

If the lights should go out in the tunnel and a blood-curdling scream is heard: call Hercule Poirot! ◀

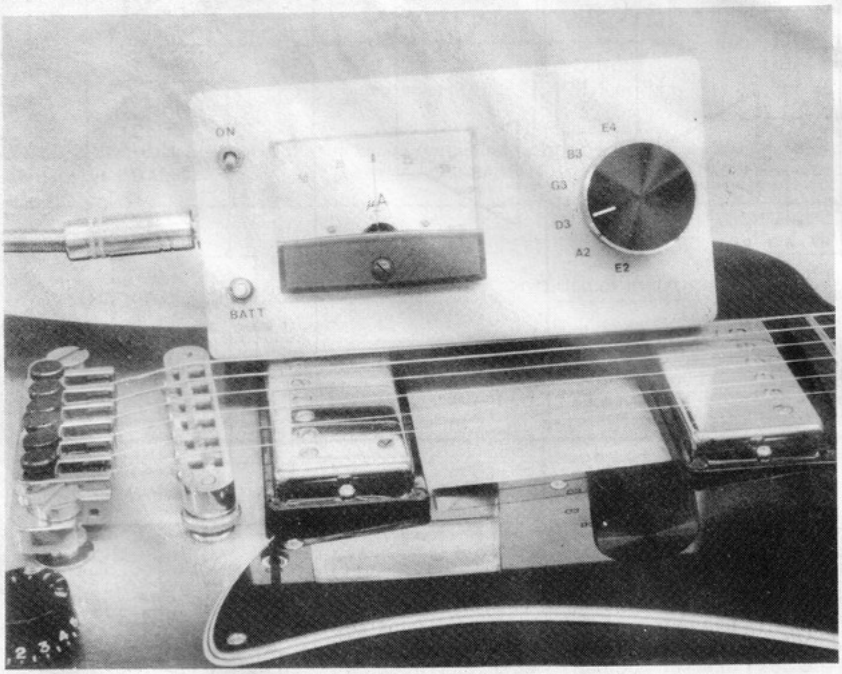


Tuning a guitar by ear is not too difficult provided you can hear what you are doing. In a crowded room or on stage, with everybody else running about with all sorts of equipment, tuning 'by eye' is definitely to be preferred. It is not surprising therefore, that electronic guitar tuners are quite popular with professionals.
Amateurs (and novices) would also like to have one of these units, but they soon discover that the 'real thing' tends to be expensive. A home-construction design would be ideal, provided it works properly, and is easy to use. In other words they are looking for the circuit described here!

guitar tuner

tuning by eye . . . . . .

The problem with guitar tuning is very rarely the guitar itself. It is usually the surrounding noise and confusion that seems to reach a peak just at the wrong moment. Many guitarists have realised that these problems can be overcome with a visual tuning aid. The circuit described here is purely electronic and, most important, it is very accurate.



Most commercial units use a moving coil meter to indicate the tuning accuracy. When the string is too 'low' or too 'high', the needle moves to the left or right respectively. The string is in tune when the needle is centred. This is a good system, so our circuit operates the same way. The scale is calibrated from −20Hz . . . +20Hz. Furthermore the design allows the tone of the string plucked to be retained, so that the indication changes slowly and progressively. This means that plucking each string once is often sufficient to tune it. The meter shows exactly what is going on while you turn the tuning key.
Finally the height of sophistication: the circuit is suitable for both electric and acoustic instruments!

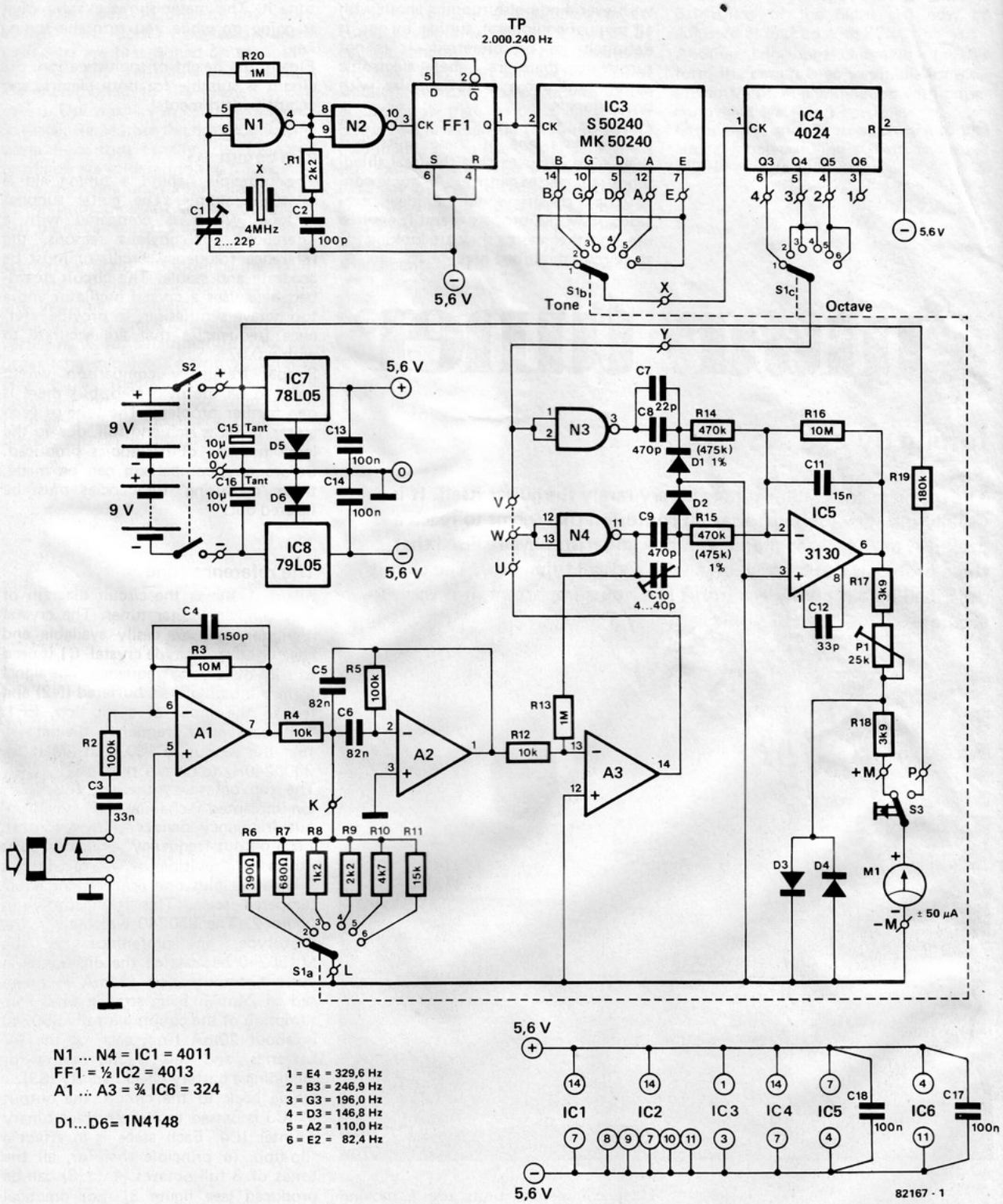
The circuit

The principle behind a tuning aid is relatively simple. The guitar supplies a tone, which is compared with a reference. For obvious reasons, the reference frequency oscillator must be accurate and stable. The circuit described here uses a crystal oscillator and a top octave synthesiser, to provide reference frequencies that are accurate to within 0.07%.
Simple frequency comparison would seem to be the next step, but there is one further problem. The tone of each guitar string is rich and full, due to the large number of harmonics produced. Before any comparison can be made, these 'confusing' frequencies must be filtered out.

The reference tone

Figure 1 shows the circuit diagram of the complete guitar tuner. The crystal oscillator uses an easily available and cheap 4MHz TV type crystal. C1 is used to trim the crystal frequency. The signal from the oscillator is buffered (N2) and fed to the input of a flip-flop, FF1. This acts as a frequency divider, so that the output to IC3 is at 2MHz (or 2000240Hz to be exact).
The top octave synthesiser, IC3, is an ion-implanted P-channel MOS synchronous frequency divider, TOS for short. Each output frequency is related to the others by a multiple of $\sqrt[12]{2}$, providing a full octave plus one note on the equal tempered scale. This is illustrated in figure 2. The S50240 was used in the prototype, in preference to the MK50240 because of the difference in current consumption (14mA as opposed to 24mA). Even so, the total consumption of the circuit with the S50240 is about 20mA from each of the 9V batteries, and this is the reason for including a battery check facility (S3).
Going back to the circuit, the output of IC3 is passed to a seven stage binary counter IC4. Each stage is in effect a flip-flop. In principle therefor, all the tones of 8 full octaves (1 . . . 8) can be produced (see figure 3). For practical reasons, unfortunately, the division ratios in the top octave synthesiser cannot be more than good approximations, and so the actual frequencies produced are a maximum of ± 0.07% out.
The frequencies within the darker rectangles in figure 3 are the actual tones for each string of a normally strung standard 6 string guitar: E2

1



N1 ... N4 = IC1 = 4011
FF1 = ½ IC2 = 4013
A1 ... A3 = ¾ IC6 = 324

D1...D6= 1N4148

1 = E4 = 329,6 Hz
2 = B3 = 246,9 Hz
3 = G3 = 196,0 Hz
4 = D3 = 146,8 Hz
5 = A2 = 110,0 Hz
6 = E2 = 82,4 Hz

Figure 1. The circuit diagram of the complete tuner. For use with an acoustic guitar R2 = 10 K and C3 = 220 n.

or bottom E (sixth string), A2, D3, G3, B3, and E4 or top E (first string). S1b selects one of the five desired notes in the top octave and passes this signal to IC4. The outputs of this IC cover a total of three octaves, to enable the tuner to be effective for a six string guitar. Output Q6 (octave 1) of IC4 is not connected, but it can be used for tuning bass guitars. With S1b and S1c connected as shown, the desired tones are produced in their correct octaves.

2

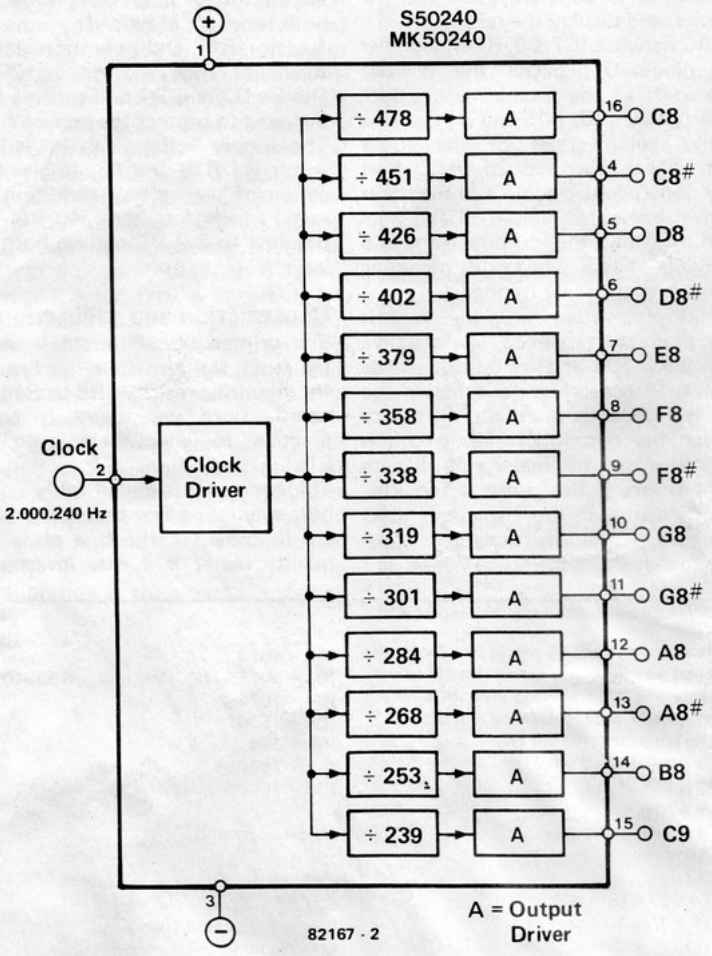


Figure 2. The block diagram of the top octave synthesiser, used to generate the basic reference tones.

The input stage

As already mentioned, the harmonics produced by the guitar can pose a major problem. The best solution is to provide adequate filtering at the input. At the same time it is useful to set a fairly high gain in the input stage, so that the guitar signal can be measured well into the decay time. This makes tuning that much simpler, since you do not have to pluck the string so often. In the actual circuit, opamp A1 is set to a gain of 100X. C3 and C4 have been included in the network around A1 as a general band-pass filter, to get rid of some of the 'dirt' in the guitar signal. The input impedance is 100 kΩ, which should cater for nearly every guitar.

Quite a narrow band-pass filter is constructed around A2. The band-width is only 40 Hz, effectively eliminating the harmonics and passing the fundamental only. The basic principle is shown in figure 4. The centre frequency is determined by R6 to R11, as selected by S1a. It should be noted that the resistors correspond to R3 in figure 4, so they have no effect on the gain or bandwidth. As a matter of interest the gain of the network is about 5X. Note that if other tones are selected (for tuning bass guitars), the values of R6 . . . . R11 must be modified accordingly!

A3 and N4 act as a schmitt-trigger, converting the output signal from A2 into a square wave. The hysteresis is 110 mV.

The comparison

We now have a reference frequency at the output of N3 and the guitar fre-

3

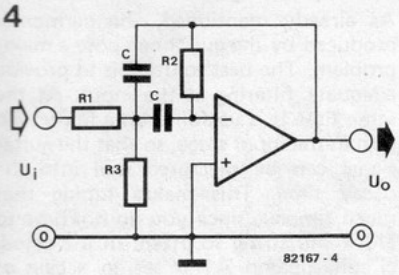
tone and frequency for musical instruments

tone	octave								
	0	1	2	3	4	5	6	7	8
C	16.3516	32.7032	65.4064	130.813	261.626	523.251	1046.50	2093.00	4186.01
C#	17.3239	34.6478	69.2957	138.591	277.183	554.365	1108.73	2217.46	4434.92
D	18.3540	36.7081	73.4162	146.832	293.665	587.330	1174.66	2349.32	4698.64
D#	19.4454	38.8909	77.7817	155.563	311.127	622.254	1244.51	2489.02	4978.03
E	20.6017	41.2034	82.4069	164.814	329.628	659.255	1318.51	2637.02	5274.04
F	21.8268	43.6536	87.3071	174.614	349.228	698.456	1396.91	2793.83	5587.65
F#	23.1247	46.2493	92.4986	184.997	369.994	739.989	1479.98	2959.96	5919.91
G	24.4997	48.9994	97.9989	195.998	391.995	783.991	1567.98	3135.96	6271.93
G#	25.9565	51.9131	103.826	207.652	415.305	830.609	1661.22	3322.44	6644.88
A	27.5000	55.0000	110.000	220.000	440.000	880.000	1760.00	3520.00	7040.00
A#	29.1352	58.2705	116.541	233.082	466.164	932.328	1864.66	3729.31	7458.62
B	30.8677	61.7354	123.471	246.942	493.883	987.767	1975.53	3951.07	7902.13

frequency in Hz

Figure 3. The frequencies of the tones in each octave. The 'blocked' frequencies are the ones used for the guitar tuner.

4



centre frequency : $f_o = \frac{1}{2\pi C}\sqrt{\frac{R1+R3}{R1\,R2\,R3}}$

gain at f_o: $-A_o = \frac{R2}{2R1}$

Q-factor: $Q = \pi\, R2\, C\, f_o$

bandwidth: $B = \frac{1}{\pi\, R2\, C}$

Figure 4. This second order filter is used in the circuit to eliminate the harmonics produced by a guitar string.

quency coming from N4. The next and final step is to compare these two frequencies, and display the result.
One RC network (C7, C8, R14), together with diode D1, passes the positive going edges of the square-wave to IC5. Similarly C9, C10, R15 and D2 pass the negative going edges of the guitar signal. These two sets of very short pulses (one positive-going and the other negative) are added, amplified and integrated, so that the output from IC5 (pin 6), is at 0 V when both incoming signals are at the same frequency.
Alternatively, when the guitar tone is lower than the reference, less negative pulses reach IC5 and its output swings negative. In general the output voltage from IC5 depends upon the difference between the two tones. The circuit is arranged so that the meter will indicate left of centre if the guitar is too low, right of centre if too high, and dead centre when the instrument is accurately tuned.
The trimmer C10, is used to calibrate the circuit for 0 V at the output (when both tones are identical).
Resistor R17 and potentiometer P1 set the meter range (−20 Hz . . . +20 Hz).
Diodes D3 and D4 and resistor R18 are included to protect the meter.
The supply voltage can be fed to the meter via R19 and S3, to give an indication of the battery condition. If the meter reads less than 40 μA (corresponding to 7.2 V), replace both batteries.

Construction and calibration

The printed circuit board is shown in figure 5. No provision has been made for mounting resistors R6 to R11 on the board, since we found it easier in practice to wire these onto switch S1a.
The components are all fairly common, but, even so, a few practical comments are in order. In the first place a good quality meter is a wise investment, as

Parts List

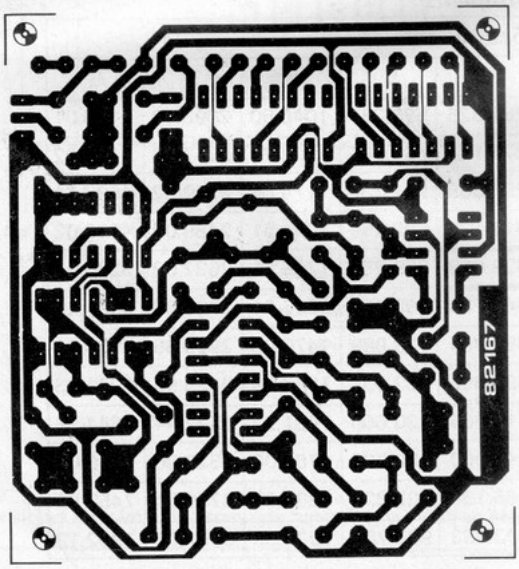
Resistors (1/8 W):
R1,R9 = 2k2
R2,R5 = 100 k
R3,R16 = 10 M
R4,R12 = 10 k
R6 = 390 Ω
R7 = 680 Ω
R8 = 1k2
R10 = 4k7
R11 = 15 k
R13,R20 = 1 M
R14,R15 = 470 k (475 k) 1% precision
R17,R18 = 3k9
R19 = 180 k
P1 = 25 k preset

Capacitors:
C1 = 2 . . . 22 p trimmer
C2 = 100 p
C3 = 33 n
C4 = 150 p
C5,C6 = 82 n
C7 = 22 p
C8,C9 = 470 p
C10 = 4 . . . 40 p trimmer
C11 = 15 n
C12 = 33 p
C13,C14,C17,C18 = 100 n
C15,C16 = 10μ/10V tantalum

Semiconductors:
D1 . . . . D6 = 1N4148
IC1 = 4011
IC2 = 4013
IC3 = MK 50240 (Mostek), S 50240 (AMI)
IC4 = 4024
IC5 = 3130
IC6 = 324
IC7 = 78L05
IC8 = 79L05

Miscellaneous:
X = 4MHz crystal
S1 = 6 way double decked wafer
S2 = double pole two way
S3 = press-button (two way)
M1 = moving coil meter
(−50μA . . .0 . . .+50μA)
2 battery terminals
1 standard jack socket (6.3 mm)

5



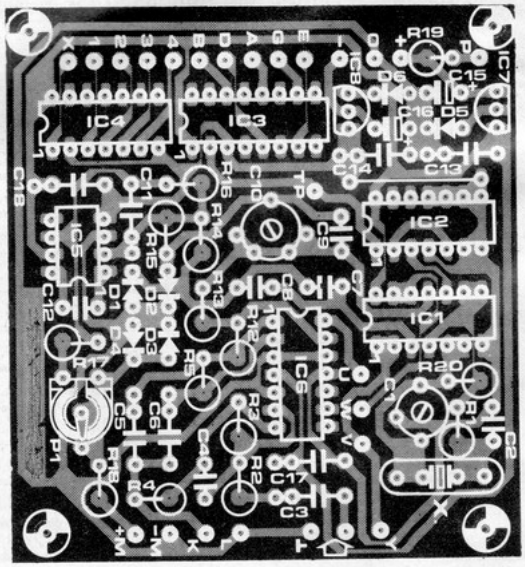


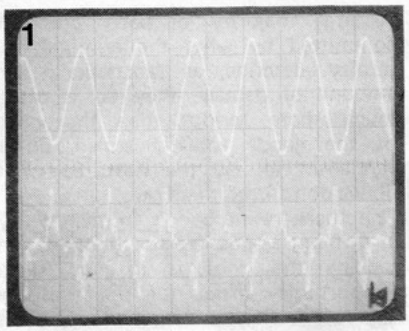
Figure 5. The printed circuit board for the guitar tuner.

some of the cheaper variety are not sufficiently accurate. Then although the prototype used a double decked wafer switch for S1a . . . S1c, it is also possible to use one of the new multi-position slide switches that are available. The size of the case depends on the components used for the meter and switches, but we found a plastic box (Vero) size 15 x 8 x 5 cms was just right for the items we used (see photo). Bear in mind that the meter should be in a vertical position (not laying down), otherwise the accuracy is impaired. The case should be reasonably stable, so that it is not easily pulled over and onto the floor by the weight of the guitar lead. For the same reason, make sure that the case is robust!

There is nothing critical about the mounting of the components onto the printed circuit board, only that care should be taken in handling the ICs. Note that the resistors are mounted vertically.

The calibration of the circuit is equally straightforward:

- insert a wire link between points V and W, as shown in the circuit diagram in figure 1, and set P1 toits mid position.
- beg, borrow, or steal a high quality frequency counter – a model with 7 digit accuracy. Do we hear panic in the ranks? Fear not, dear majority—just skip the next sentence. If one is lucky and has a counter, simply connect it to point TP (the output of FF1) and adjust C1 for a reading of 2000240 Hz. If no frequency counter is available, just set C1 to its mid position. The frequency will never be more than 0.03% out, a mere trifle which can be discounted.
- Switch S1 to E4 and adjust trimmer C10 so that the meter is zeroed.
- remove link W-V and insert link W-U (the final situation).
- plug in a guitar and tune in E4: the first string open. Make sure the needle of the meter is exactly at 0 (string perfectly tuned) before going on any further.
- once open E (first string) is tuned, play the note F4 (349 Hz), which is first fret, first string. This is 20 Hz above and can therefore be used to calibrate the scale of the meter. Adjust P1 so that the meter reads +50 μA. This calibrates the meter to ± 20 Hz.



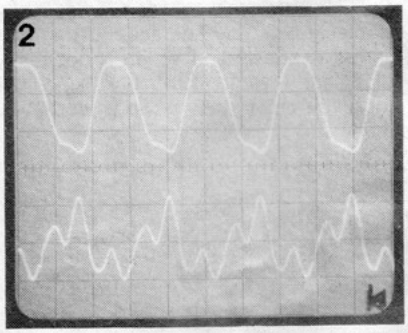


Photo 1 and photo 2. The lower trace shows an unfiltered guitar signal. As can be seen, this could pose problems if it was applied to a schmitt-trigger. The upper trace is the filtered signal which can be handled easily. Photo 1: 330 Hz: Photo 2: 82 Hz

Practice

The tuner was tested 'on stage', where it performed perfectly (which is more than could be said for the musicians who tried it!).

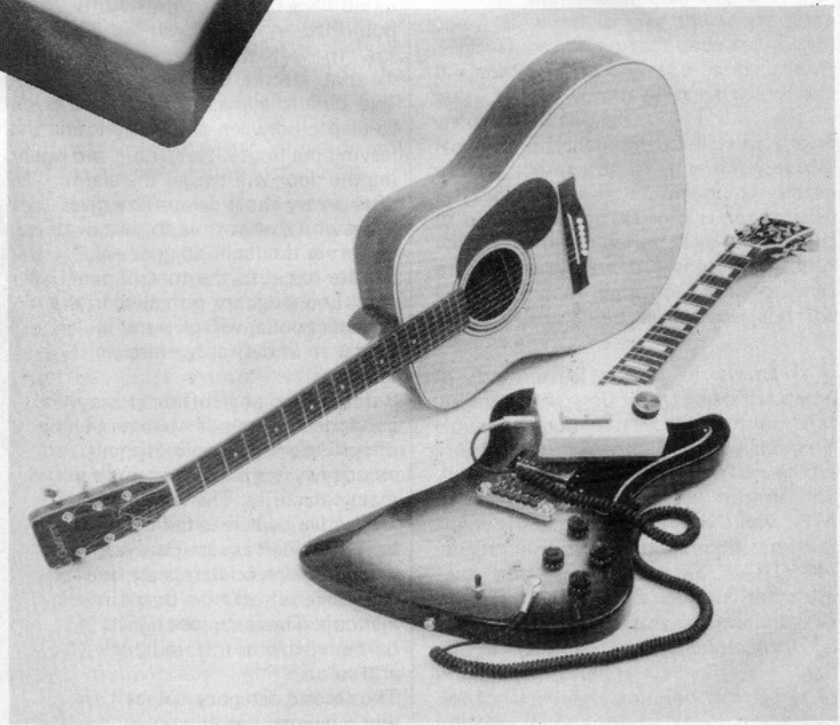
Its ability to display tones either one semitone above or below standard tuning was also found useful, especially for some fingerpicking techniques.

It had the same no-nonsense operation as the expensive commercial models.

The tuner also works very well with acoustic guitars. A good quality condensor microphone can be plugged into the standard jack socket of the tuner. However it is better to provide a second input, with R2 replaced by a 10 k resistor and C3 increased to 220 nF. This is because the microphone signal is not as high as that of the guitar and therefore the gain of A1 has to be increased to 1000 X. These modified values can also be selected by means of a small changeover switch at the input.

Final note

Constructors not wishing to use a battery supply can utilise the power supply of the Elektor Artist guitar pre-amp, published in our May 1982 issue. The positive rail can be taken from the positive side of C67 (refer to the circuit diagram of the Artist), the 0 from the negative side of C67, and the negative rail from the negative side of C68. This gives a supply of ± 8 V, which is ideal for our purpose. S3 and R19 will not be required in this case. Have a good tune up!



cerberus

electronic watchdog

We live in violent times. The crime rate is on the 'up and up', especially burglaries. More to the point is the fact that petty 'break-ins' are now almost common place. Sophisticated alarm systems exist, but they tend to be expensive and are meant to keep out the professional. What the average householder needs is a simple, good quality, low cost device which detects 'entry' and then scares the living daylights out of the intruder.
Hence Cerberus . . . . . ! A circuit with the added facility of 'barking' every time someone arrives at the door.

A large majority of petty crime is committed by what the criminal fraternity describe as 'amateurs'. The amount of damage they do is often much more serious than the value of the goods actually stolen. Sheer vandalism to say the least. So what do we do to keep them out.
The cheapest method is to make entry as difficult as possible for the thief, and locking the door is a good start. 'Opportunity makes the thief', as the Earl of Essex said four hundred years ago. However, his solution is not really viable in this day and age. Putting bars across windows and so on is not really nice and would probably send the local fire chief into fits. So what do you do?

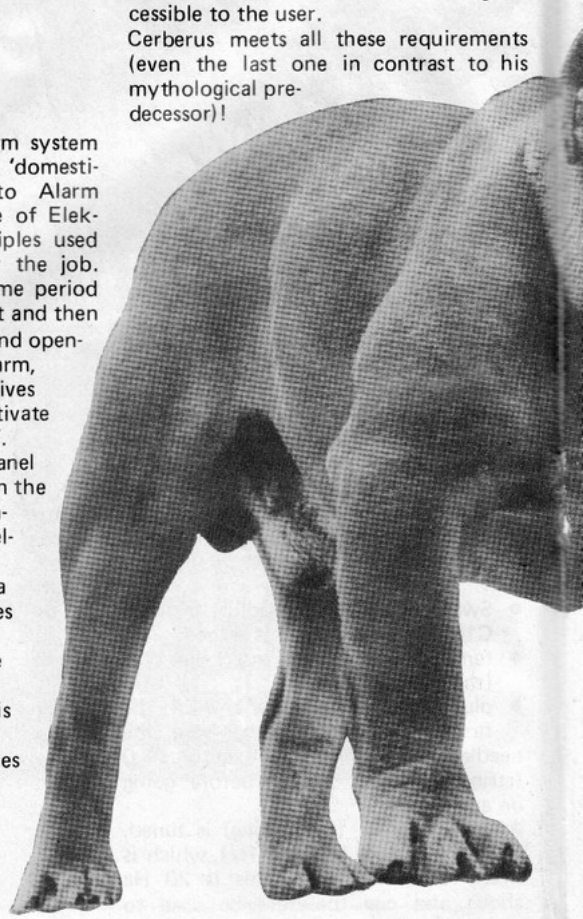
Some kind of electronic alarm system is required. For instance, a 'domesticated' version of the Auto Alarm published in the March issue of Elektor. In fact the basic principles used in that circuit are ideal for the job. The circuit allows a short time period to elapse between activating it and then leaving the house. Returning and opening the door will trigger the alarm, after a very short delay. This gives the lawful owner time to deactivate it, before the 'balloon goes up'. Failure to get to the control panel quickly enough, or punching in the incorrect code, will give any intruder an undesirably noise welcome.
Before we go any further it is a good idea to look at what types of system are available. Home security systems come in three main categories. The first two are 'active', whereas the third is best described as semipassive.
The most simple alarms are ones which are set-off by a break in a circuit. These can use light (either visible or infrared), and so on.
The second category detect any movement within a given area. These are very complex affairs, often based on some kind of radar. In general they are too sensitive and expensive for normal home use.
Finally, semi-passive systems are not really alarms in the true sense. They simulate the presence of an accupant by turning lights on and off, opening and closing curtains in a true to life sequence. Hopefully they scare off the amateurs.

The quality of alarms

How sophisticated should a domestic alarm be? This is not an easy question to answer. The better the quality, then normally the higher the price. If you want value for money the points to consider can be itemised as follows.

- Reliability. It must always work at the right time, and never 'for no apparent reason'. Some of the expensive models have been known to be triggered by a fly hitting the window.
- Simplicity. This applies both to installation and operation.
- Economy. It must be independent of the mains supply, but the batteries must last a reasonable length of time. The last thing you want to do is to change them every time you go out.
- Effectivity. In other words, the thief must be made to panic and the neighbours and police should be able to hear it going off.
- Anonimity. The unit should blend in with the decorations and be unobtrusive, while at the same time being accessible to the user.

Cerberus meets all these requirements (even the last one in contrast to his mythological predecessor)!



Working principles

The alarm is switched on by means of a pushbutton (S2). When it is armed, operating a further pressbutton (S3) has the effect of temporarily disabling it for a period of 10 . . . 15 seconds. This allows you to leave the house without waking the dead. Once the door is closed behind you the alarm is reactivated.

Opening the door triggers a second timer, again giving a delay of 10 to 15 seconds. This is sufficient for you to punch in the correct code (using S4 . . . S13) to deactivate the alarm. If you do not get to the box in time or enter the wrong code, the alarm will sound. Another function of the system is to announce the arrival of visitors. In this mode it gives a short bleep whenever the door is opened, in much the same way as the bell that rings when someone enters your local store.

The circuit

Figure 1 shows the circuit in block diagram form. The control panel of the system consists of a keyboard with 12 keys (S3 . . . S14). The only other controls are the pushbutton S2 and the function selector S1 (Alarm or visitor arrivals).

The heart of the circuit is the 'logic and control' section, which consists of a single IC.

The starter is used to arm the system; the delay circuit allows the user to leave

1

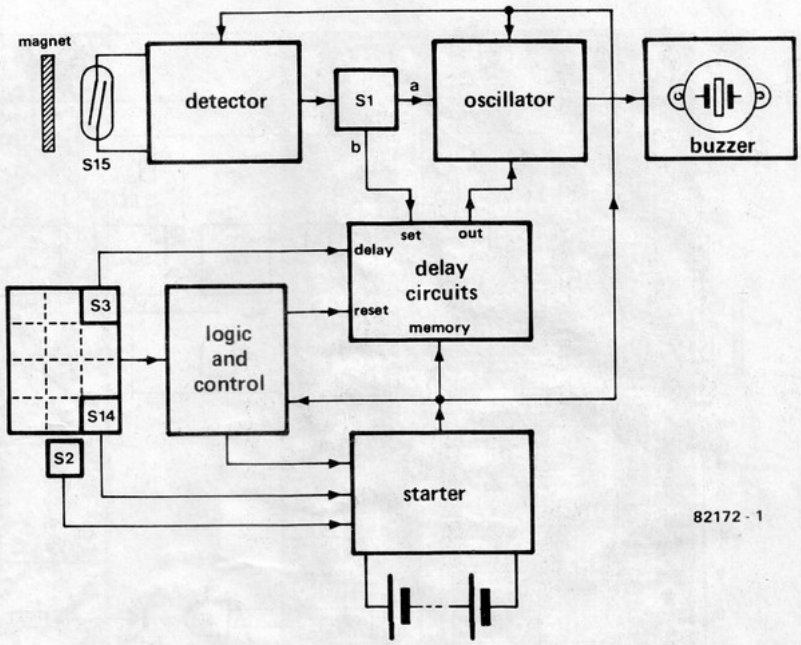


Figure 1. The block diagram shows the principal sections of the alarm system.

and enter without triggering. A detector is required to establish when the door is opened and, finally, an oscillator produces the audio signal that drives the buzzer.

Figure 2 shows the circuit diagram of the complete alarm. As a result of depressing S2, T4 conducts. This in turn provides base drive for T3: the circuit latches 'on'. Initially the input of N2 is pulled high, via C8. This caters for power-up reset, after all we do not want the alarm to sound instantly!

Now let us assume that we want to pop down to the local for a quick pint. Operating S3 sends a trigger pulse to the multivibrator MMV1 (pin 4), initiating the delay cycle. The delay time is defined by the RC network connected to pins 1 and 2. With the values shown in the circuit diagram, the total delay is 12 seconds. Provided the door is opened during this period, the circuit will remain inactive indefinitely, only 'arming' when the door is closed.

Once the circuit is armed, the door causes the reed relay S15 to close. T1 now conducts, sending a pulse to the clock input of the flip-flop FF1 (pin 11). Its Q output now goes 'high' (logic 1), and as a result the monostable multivibrator MMV2 is triggered by the pulse arriving at pin 12. This starts a new delay period determined by the RC network connected to pins 14 and 15. During this time the lawful owner can get to the keyboard and punch in the correct code to disarm the alarm. In the example given in the circuit diagram, the keyboard is wired to give the secret code 3058. Once the correct code is entered, the command circuit IC5 sends a reset pulse to the various parts of the circuit via gates N2 and N3.

Now suppose an intruder gains access to the keyboard, or the householder forgets the code . . . for some reason or other, the correct code is not entered within the delay period. The clock input of FF2 receives a trigger pulse; output Q of FF2 goes high; the oscillator built around N6 . . . N8 is enabled and the alarm sounds.

In the normal course of events it is unlikely that you will forget the code. However, you must bear in mind that you have 10 seconds from the moment you depress the first key, to enter the complete code. If desired this can be followed immediately by key S14 which deactivates the circuit. In that case both inputs of the NAND N4 become logic 1, its output therefore is logic 0, so T4 ceases to conduct. The circuit will remain dormant until S2 is again depressed.

So far we have assumed that S1 is in position 'b' (alarm).

2

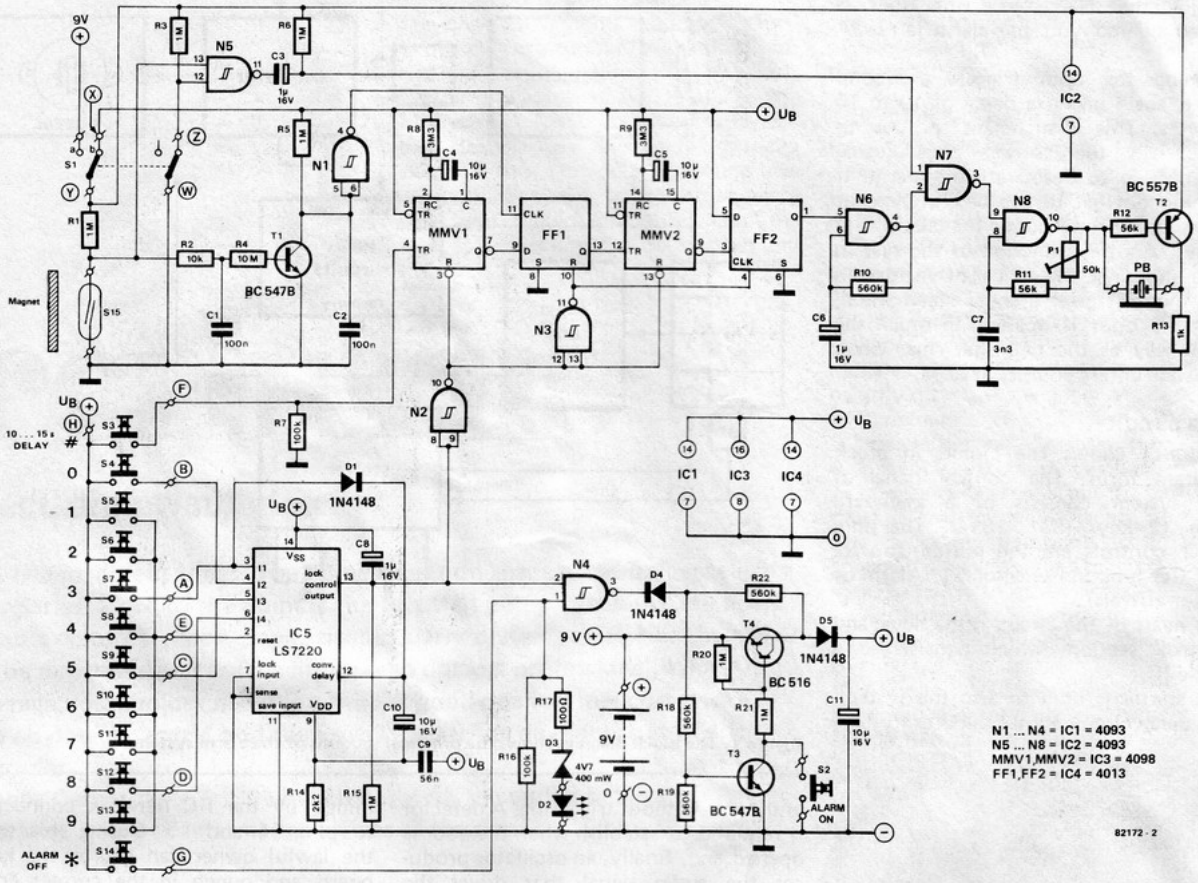


Figure 2. The complete circuit. As drawn here, the code for deactivating the alarm is 3058; this can be changed to any other four-digit number.

- Switching over to position 'a' puts the circuit in 'doorman' mode (arrival announcer). Every time the door is opened the alarm will sound for one second. This will happen irrespective of whether the alarm is activated or not (S2 depressed). With S1 in position 'a' and an activated alarm, both functions are combined: first the buzzer will sound for one second and then 12 seconds later, the actual alarm signal will be emitted.

S14 has two purposes. The first, already described is to deactivate the system (after entering the code). The second is a system check. When S14 is operated to shut down the alarm, LED D2 should light briefly to indicate that the battery is still good. If nothing happens press S2 to make sure the alarm is on, wait a few seconds and then try S14 again. Still nothing? Then what we have is a dead battery or broken LED.

Construction

The printed circuit board is shown in figure 3. Any type of keyboard will do, as long as it is possible for all the keys to be connected to a common rail (see figure 2). For this reason a so called matrix keyboard is unsuitable. The code given by the connections shown in figure 2 is merely a guide line. Any four digit code can be programmed by connecting the appropriate keys to the I1 . . . I4 inputs of IC5. Remember to connect all the other keys to the reset pin (E).

Potentiometer P1 is used to set the frequency of the buzzer tone, to obtain maximum output.

Should you wish to extend the time allowed for entering the code and depressing S14 (to deactivate the alarm), then this can easily be achieved by increasing the value of C10. The delay times of MMV1 and MMV2 depend on the values of capacitors C4 and C5.

Installation

The complete circuit including batteries can be mounted in a small box (12x6x4 cms). This makes it suitable for mounting just about anywhere. The important thing is to camouflage the unit reasonably well without making it inaccessible, so that you can get to it during the critical first 10 seconds.

The best position for the reed switch (S15) is in the doorjamb, but, no matter where it is positioned remember to discreetly hide the connection wires. The distance between the reed switch and the magnet should be around 6 mm with a maximum of 8 mm.

The consumption of the circuit in a 'stand-by' situation is around a few

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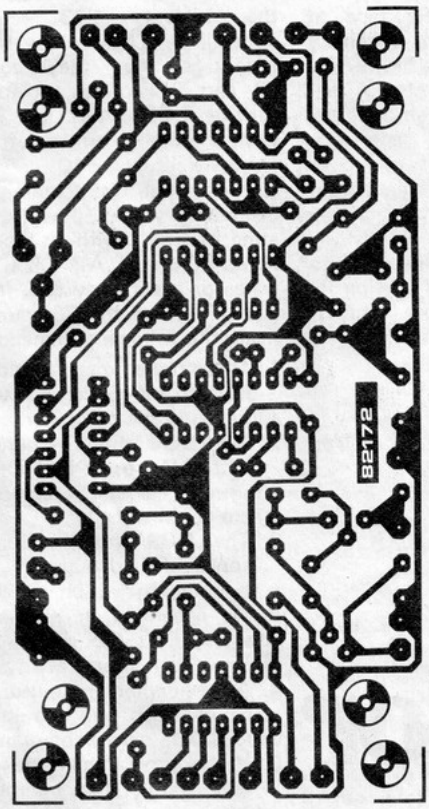


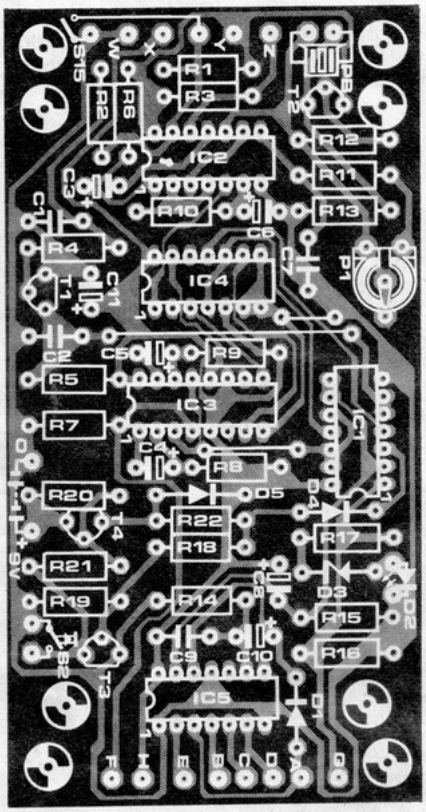


Figure 3. The printed circuit board for Cerburus is shown here. It was designed to fit the type 202-21029J case from Vero. The completed unit should be mounted in a position that is out of sight but can be reached easily in less than ten seconds. All wiring to and from the unit should be hidden if possible.

nA. When activated this increases to about 50 μA , or 10 μA in the 'doorman' mode. For good reliability we strongly suggest the use of alkaline batteries.

Cerberus: mythological multi-headed dog guarding the entrance to the underworld.

Parts list

Resistors:
R1,R3,R5,R6,R15,R20,R21 = 1MΩ
R2 = 10 k
R4 = 10MΩ
R7,R16 = 100 k
R8,R9 = 3M3
R10,R18,R19 = 560 k
R11,R12 = 56 k
R13 = 1 k
R17 = 100 Ω
P1 = 50 k preset

Capacitors:
C1,C2 = 100 n
C3,C6,C8 = 1μF/16V
C4.C5.C10.C11 = 10μF/16V
C7 = 3n3
C9 = 56 n

Semiconductors:
D1,D4,D5 = 1N4148
D2 = LED
D3 = zener 4V7/400mW
T1,T3 = BC 547B
T2 = BC 557B
T4 = BC 516
IC1,IC2, = 4093
IC3 = 4098
IC4 = 4013
IC5 = LS7220

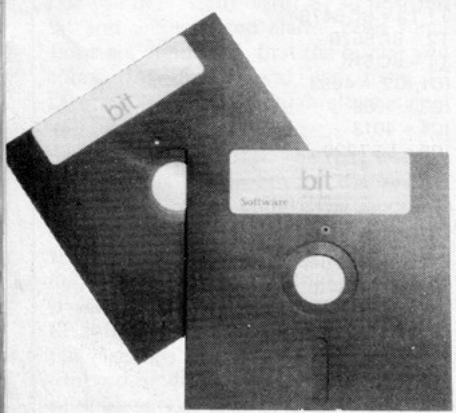
Miscellaneous:
S1 two way double pole switch
S2 press button
S3 . . . S14 12 key keyboard, one common rail. (e.g. TKC type BLE 2)
S15 = reed switch
PB = piezo buzzer (PB2711)

G. de Cuyper

floppy-disk interface for the Junior

. . . and other 6502 computers

At present the floppy disk is the most significant mass storage medium for the computer. Considering the method used for recording, it is almost incredible that computer data can be stored on a simple plastic disk at such speed and with such precision. This article will point out everything that has to be taken into account before one single bit can be stored on the plastic disk. The hardware of the floppy disk interface is designed to be universal. Not only Junior Computer fans, but also the owners of a KIM, SYM, AIM-65, ACORN and other computers can use this low-cost interface to extend their computer to a real personal computer. Even an interface for connecting the EPSON printer is provided.



Computer fever broke out here in Europe about eight years ago. The first 8-bit processors were even available at a hobbyist's budget. The great change, however, came in 1976 when Shugart brought the first 8-inch drive onto the market. Until then computer data had to be stored on punched paper tape or inconveniently on magnetic tape at speeds that are considered extremely slow today. The floppy disk revolutionized rapid data interchange between the computer and an external mass storage device. Rapid paper tape readers only achieved rates of up to 15 kilobaud (baud = bit/second) at best. Paper tape punches were barely able to exceed 700 baud. Unless the user is to go to great expense with magnetic tape recording using a cassette recorder, the upper limit is 1200 baud at a tape speed of 4.75 cm/s.

But even floppy disks have their disadvantages. Although the round plastic disks do not cost more than good chrome-dioxide cassettes, the drive unit for floppy disks is fairly expensive. The computer user will have to pay about 120 to 190 pounds for a floppy disk drive. If one considers that two drives are required for convenient operation with a computer, the investment is quite substantial.

The price barrier

Since the prices for floppy disk drives are not likely to drop much lower, it was decided to save costs in another area when implementing a DOS (DOS = disk operating system) for the Junior Computer. We had to make a choice between employing a floppy disk controller and a controller using a few TTL ICs and some software. The 1771 or 1791 from Western Digital or the Motorola 6843 are suitable as controllers. These chips have the disadvantage that they cost between 17 and 35 pounds. A further disadvantage is that not much 6502 software is available on the software market for these controller ICs.

Our objective was to equip the Junior Computer with a powerful disk operating system, without forgetting the KIM, SYM and AIM-65 friends. Hardware for the floppy disk interface was not to exceed the 35 pound limit. We made the following demands of a DOS:

1. The programmer should no longer have to be concerned with absolute addresses in the computer.
2. The DOS should operate together with a Microsoft BASIC. The BASIC interpreter should understand DOS macro commands.
3. The DOS should operate with a convenient debugger. A debugger is a program which allows software to be generated in machine language and tested. It should also be possible to place break points at any locations.
4. An assembler and editor should also be provided and should understand various DOS macro commands.
5. If the programmer makes an incorrect input, the computer should enable immediate analysis of the syntax and operating errors with precise error messages.
6. There should be a lot of good and cheap software available on floppy disks for the DOS:
   - Games programs
   - Bookkeeping programs
   - Programs in BASIC and Assembler
7. The DOS must be easily adaptable to any 6502 computer.
8. The DOS must be capable of generating random files. Random files are data files on the floppy disk into which data are written and which are produced during execution of a BASIC program.

As can be seen from these requirements, we made high demands of the disk operating system. For this reason we chose an operating system that is widely used in the USA and Europe: the DOS is from Ohio Scientific and is known as the 'Ohio Scientific OS-65D Operating System'.

Ohio Scientific also supplies the popular computers 'superboard C1P, C4P and C8P'. The software developed for these computers (and there is a good deal of it) can be easily adapted to the Junior Computer and other 6502 systems by modifying a few bits in the DOS main program (called KERNEL). Two versions of Ohio's DOS are available at present:

1. OS-65D V3.1 consisting of

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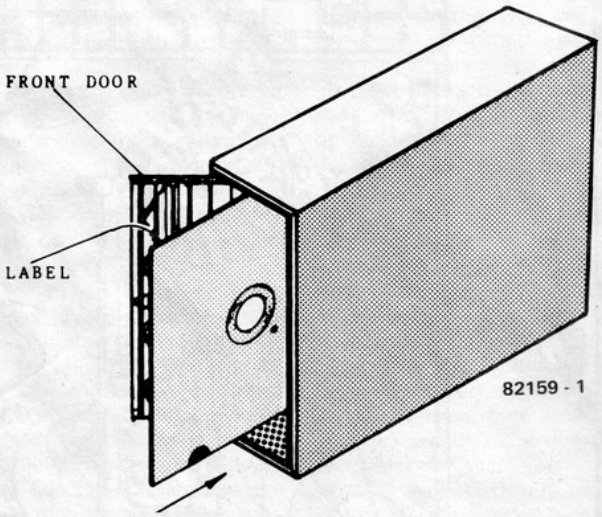

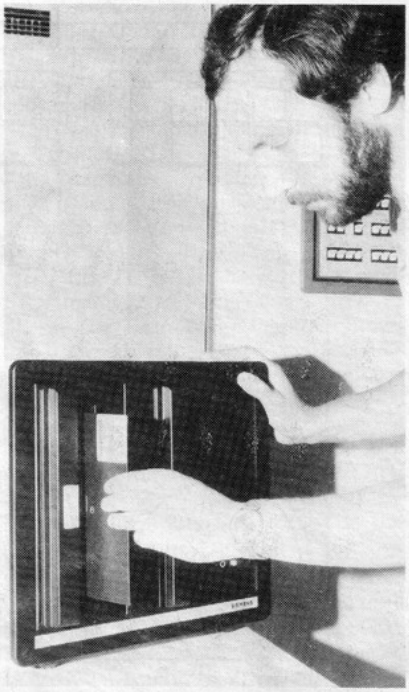

Figure 1 shows how a diskette is inserted into the drive. The label of the diskette faces the door of the drive.

– A 5-inch diskette
– A manual of approximately 75 pages.
– The price of OS-65D V3.1 including manual is approximately 30 pounds – relatively inexpensive.

2. OS-65D V3.3 consisting of
– Five 5-inch diskettes accommodating various user-support programs (more than 17 utility programs altogether, which greatly facilitate programming).
All programs are written in BASIC and can thus be easily modified by the user if necessary.
– A fresh diskette
– A 250-page manual and detailed instructions for working with the DOS, BASIC and Assembler. Also contained are a BASIC manual and an Assembler manual.
– The price of OS-65D V3.3 including all manuals is approximately 60 pounds. Considering the expensive documentation of OS-65D V3.3, this price is certainly justified to say the least.

We adapted both versions to the Junior Computer and both versions have been working for many months without any problems and to our full satisfaction.
Before being able to work with the extensive DOS from Ohio Scientific, however, a good deal must be known about the operating system. The Ohio manuals are very well written, but one must be familiar with computer techniques to understand the manuals. For this reason we shall try to provide our readers with the necessary knowledge concerning a disk operating system, step by step. First we shall generally describe the manner in which the data are stored on a floppy disk and will then discuss the recording method of Ohio Scientific. A functional description of the mechanical aspects of a floppy disk drive will also be included.
As shown in figure 1, each floppy disk drive has a door at the front. This door must be opened to insert or remove a diskette. The door should not be closed until the deskette has been fully inserted into the drive. Otherwise there is a risk of damaging the diskette. Fitted to the door of the drive is a switch which closes a contact when the door is closed.

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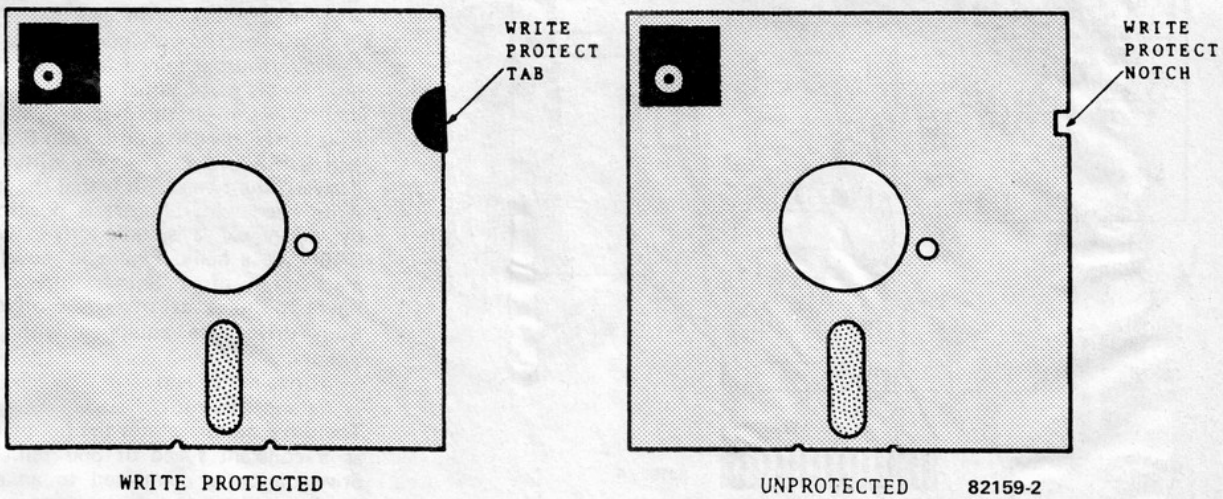

Figure 2. The diskette has a notch on one edge. If this notch is covered by a non-translucent medium, the diskette is write-protected.

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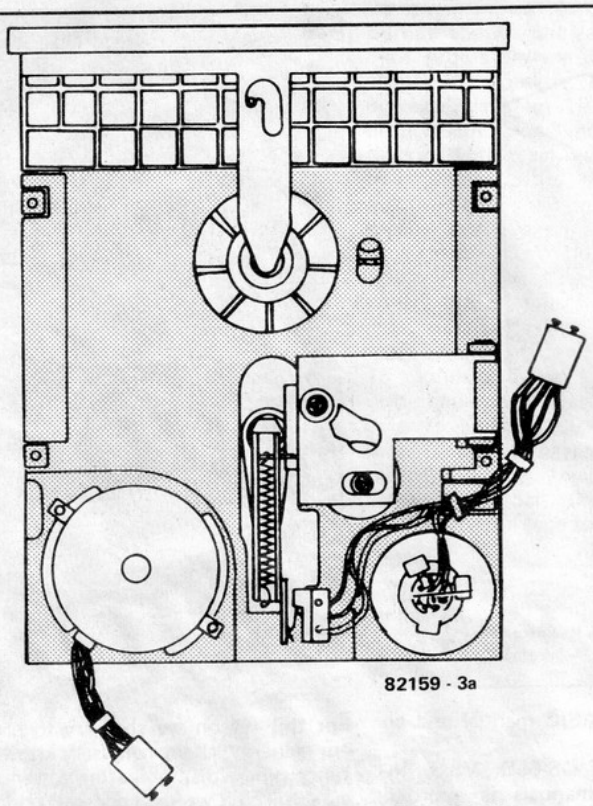

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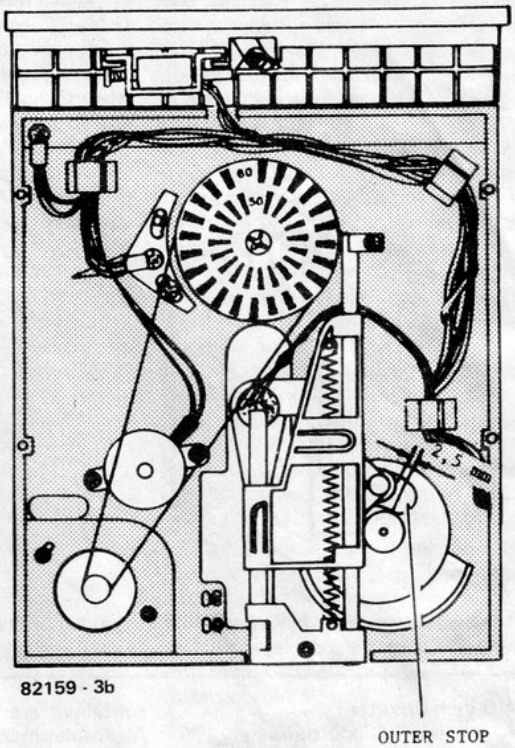

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Figure 3a shows a Shugart drive and figure 3b shows a BASF drive.

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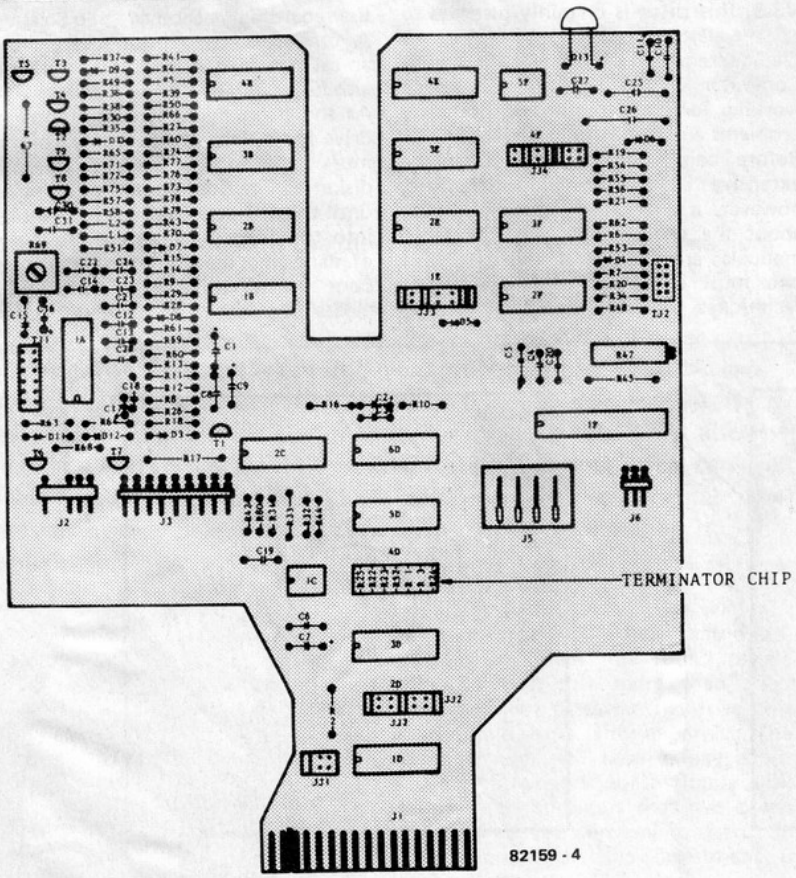

82159 - 4

Figure 4. This is the component side of a BASF 6106 drive. The computer transmits and receives data to and from the drive via J1. Plug JJ1 is in position 'A'. The plug of JJ1 must always be in the position shown when a drive is used.

Thus the computer can only write data onto the diskette or read data from it when the door is closed.

Diskettes can be protected against accidental overwriting. As can be seen in figure 2, there is a notch in one side of the diskette. An optoelectronic device in the floppy disk drive monitors this notch to establish whether it is open or covered. If the notch is covered the diskette is protected against accidental overwriting. If the programmer attempts to write data onto a write-protected diskette the DOS issues an error message.

Any floppy disk drive can be utilized in principle. The only condition is that the input/output connector of the drive must be Shugart-compatible. Most 5 1/4-inch drives meet this requirement. We have tested the DOS both with Shugart and BASF drives. The only difference between the two drives is that the read/write head with Shugart is positioned by means of a spindle drive, whilst BASF use a helix. Figure 3a shows the mechanism of a Shugart drive and figure 3b shows that of a BASF drive.

Both drives are equipped with two motors:

— a drive motor and

— a stepper motor.

The drive motor rotates the floppy disk at a constant speed of 360 rpm. The drive motor is connected to an electronic regulator which keeps the rotational speed of the diskette constant, even in the event of load variations. The rotational speed of the diskette can be varied within certain limits on both

drives. The second motor is a stepper motor which handles the positioning of the read/write head of the drive. This motor is also connected to electronic control circuitry. The control circuitry is fed with pulses by the computer. Each pulse switches the stepper motor one step further. Another line is connected between the computer and the control circuitry of the stepper motor. The potential on this line determines whether the stepper motor is to move the read/write head outwards from the interior or vice versa.

The drive chassis also contains three other electromechanical components:
As its name implies, the task of the head-load solenoid is to lower the read/write head onto the magnetic surface of the diskette. If the head-load solenoid is not activated, the read/write head is raised from the surface of the diskette by a spring. On the BASF drive the head is rigidly mounted. A felt pressure disk presses the magnetic surface of the diskette against the head.

Two optoelectronic sensors are located on the drive chassis. One of these sensors emits a pulse when the read/write head is over 'track zero' (described in more detail at the end of the article). Track zero is a special recording track on almost all floppy disk drives.
The second sensor monitors the index hole which is punched in the diskette. The index hole (see figure 2) is the absolute zero mark of the diskette or, to put it another way, the 'zero degree mark' on the round plastic disk. The index hole serves to inform the computer when the diskette has made a full revolution. Thus at 360 rpm an index pulse is emitted every 166.66 ms.

To summarize, therefore, a floppy disk drive consists of the following components:

- A stepper motor for positioning the read/write head
- A drive motor to rotate the diskette at a constant speed
- An optoelectronic sensor that checks whether the read/write head is positioned over track zero
- An optoelectronic sensor that establishes whether the diskette is write-protected
- An optoelectronic sensor that monitors the index hole and emits a pulse every full revolution
- A head-load solenoid that lowers the read/write head onto the magnetic surface of the diskette.

Clearly, a good deal of electronic circuitry is required to control all the electromechanical components on the drive chassis. Read/write amplifiers are also required for the head in the drive. These amplifiers can be compared with the recording and playback amplifiers in a conventional tape recorder. However, the read/write amplifier in the drive must be able to process frequencies of approximately 125 kHz, because the baud rate for our floppy disk interface is 125 kilobaud.
All this extensive circuitry is installed in a floppy disk drive and obviously contributes to its high cost. Usually the electronic circuitry in the drive is prealigned. There is therefore no difficulty involved in connecting a drive to the Junior Computer. Figure 4 shows the printed circuit board for a BASF drive. Only two connectors are important and to the user: J1 and J5.
Connector J1 is the Shugart-compatible connector of the drive. All control signals of this connector have TTL levels. All control signals emitted by the floppy disk interface are fed to the electronic circuitry in the disk drive via J1.

Connector J5 is also Shugart-compatible and is utilized for the supply of power. The disk drive requires two voltages: 12 V/800 mA and 5 V/300 mA. Since the power consumption of a DOS computer is fairly high, we shall examine the question of power supplies in a future issue of Elektor.

Any user wishing to connect two or more drives to his computer must also

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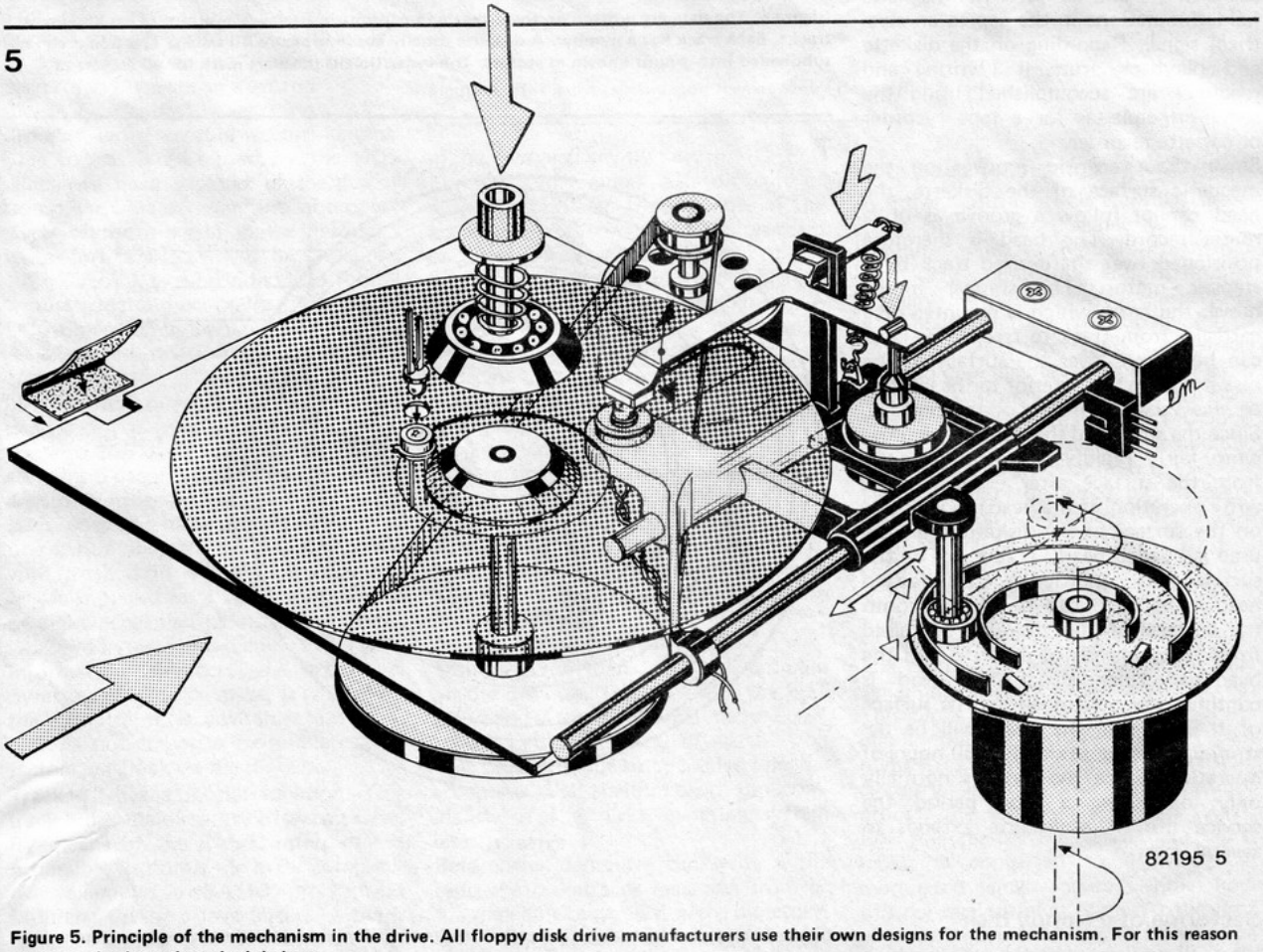


Figure 5. Principle of the mechanism in the drive. All floppy disk drive manufacturers use their own designs for the mechanism. For this reason we can only show the principle here.

take into account connector JJ1 and the terminator chip:
The terminator chip contains eight pull-up resistors and is always located in the last drive, when more than one are connected. When two drives are connected to the Junior Computer, drive A (the first one) has no terminator chip whilst drive B (the last one) contains the terminator chip. If, for example, four drives are to be connected to the Junior Computer, drives A . . . C contain no terminator chips whilst drive D (the last one) contains a terminator chip.
The drive designated as A, B, C or D is selected on JJ1 with the shorting plug. Drieve A is selected with the position shown. The following plug positions are assigned to drives B and C. Drive D does not require a shorting plug because it is clearly identifiable by the terminator chip.
Resistor R69 is for fine adjustment of the read amplifier. This resistor should never be readjusted. The quality of the read signal depends on it (freedom from jitter).

Drive mechanism

Figure 5 shows a sketch of a drive mechanism. The floppy disk is rotated by the drive motor like a record. The head makes contact with the surface of the diskette and converts the magnetic field fluctuations in the gap to an electrical signal. Recording on the diskette and playback from it ('writing and reading') are accomplished using the same principle as for a tape recorder or cassette recorder.
Since there are no grooves on the magnetic surface of the diskette, the head cannot follow a groove as on a music record. The head is therefore positioned over the desired track by a stepper motor. The stepper motor moves the head, which is mounted on a carriage, from track to track. The head can be moved over the surface of the diskette from the exterior to the interior or vice versa by means of the carriage. Since the surface of the diskette becomes worn fairly rapidly, the head is raised from the surface after every read or write operation. If the head is positioned on the surface of the diskette the term used is 'loaded head'. If it is not on the surface, this condition is an 'unloaded head'. The head can be lowered onto the surface of the diskette or raised from it by means of a spring and the head-load solenoid. If the head is continuously positioned on the surface of the diskette, the track will be destroyed after approximately 50 hours of operation. Since the head is normally only loaded for a short period, the service life of a diskette extends to several years.

Sectoring of a floppy disk

We shall now describe the way in which the data are stored on a diskette. With

6

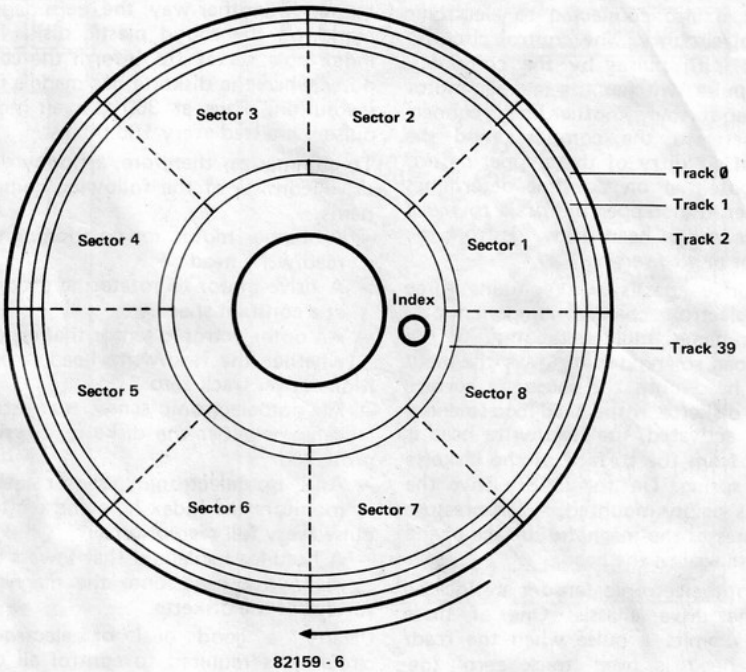


Figure 6. The data are written on the diskette in concentric circles. These circles are known as tracks. Each track has a number. A diskette usually accommodates 40 tracks. The tracks can be subdivided into groups known as sectors. The index hole is the start mark for all sectors of a track.

7

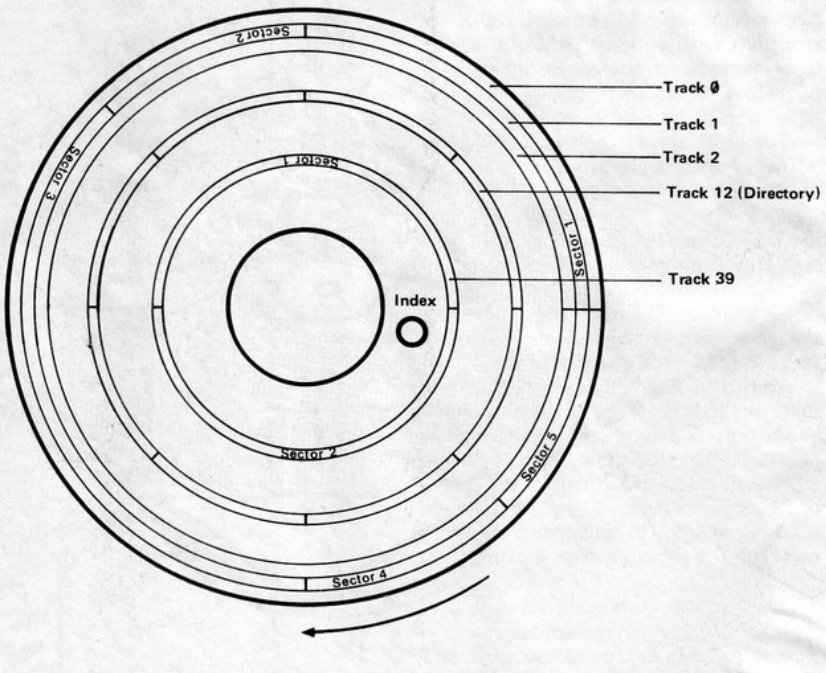


Figure 7. With soft-sectoring, the sectors can be of different lengths. In the extreme case a track consists of one or eight sectors. Track 12 is reserved for the directory with the Junior Computer.

floppy disks of the type used for the Junior Computer, the data are stored on 40 concentric rings. The width of one ring is only 0.2 mm. The outermost ring of the diskette is track zero. With most disk operating systems (including the OS-65D) this is a reference track for the other tracks on the diskette. Figure 6 shows that the diskette is further subdivided. In addition to the 40 tracks, the diskette is subdivided into sectors. For the sake of simplicity, we have used eight sectors in the example. Sector 1 always comes soon after the index hole. With OS-65D there is always a wait of 1 ms until the index pulse has decayed. Only then are the data written into the corresponding sector of the track.

There are very many formats for sectoring a diskette. The best known format is the IBM-3740 format which is not employed by Ohio Scientific. For this reason we shall not discuss the IBM format but will deal only with Ohio's own format.

The track number and sector number allow a data block written on a diskette to be clearly identified. The diskette in figure 6 has sectors of the same lengths. It is possible, however, to place sectors of different lengths on one track. The minimum data length accommodated in one sector with Ohio Scientific is a 6502 page or 256 bytes. Thus the track number and sector number are the coordinates with which a data block can be found on the diskette in fractions of a second.

Figure 7 shows the sectoring of a diskette with variable sector lengths. This format is also used by the DOS which we have adapted to the Junior Computer. Track zero, the outermost track of the diskette, has a particular write format which will be explained later. Track 1 is subdivided into several sectors: sector 1 contains two pages, i.e. 2-times 256 bytes.

A 45-degree rotation of the diskette corresponds to a data block of 256 bytes or one page. Sector 2 on track 1 is only half as long as sector 1 and only contains 256 bytes. Sector 3 on track 1 contains 5 pages. Thus 5-times 256 bytes are stored in sector 3 on track 1.

It is possible, however, to place only one sector on a track. This is the case with track 2 in figure 7. If only one sector is placed on a track, a maximum of eight pages can be stored per track, i.e. 2048 bytes. Since specific formatting information per sector, i.e. additional bytes which require space, is written on the diskette it is advisable for safety reasons not to write more than seven sectors per track on the diskette.

Track 12 has a special function. This track holds the directory of the diskette. By means of the BASIC interpreter it is possible to store a file in the computer (for example, a BASIC program, a shopping list or a love letter). A file is created in the computer when the programmer presses keys on a terminal and the computer files the information

8

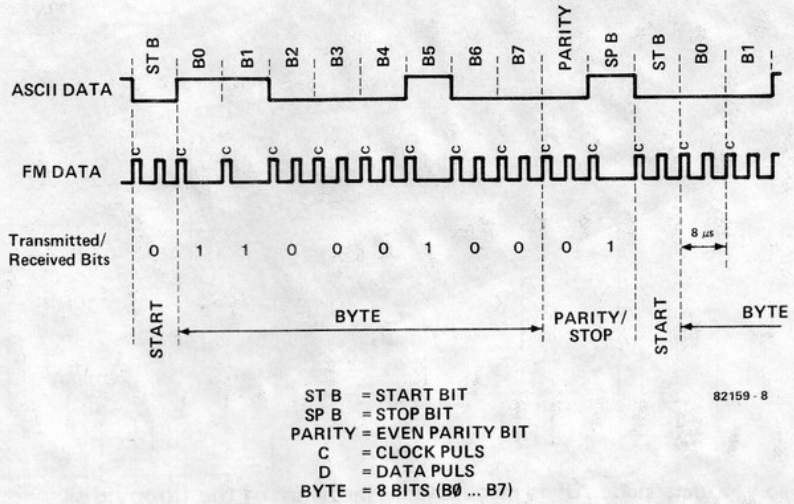


Figure 8. This is the transmission format of the floppy disk interface.

in the memory, key by key.

For any programmer it is difficult or even impossible to make a note of the track and sector in which the program or file is stored on the diskette. For this reason the Ohio DOS offers the facility for assigning names to the programs. A program name or file name may have a maximum of six alphanumeric characters and the first character must be an alphabetic character (A . . . Z). If, for example, you have written a BASIC program for calculating a circle and wish to store this program on a diskette, you can assign the program a name. You could use the name 'CIRCAL' for instance, as an abbreviation for circle calculation. You write the name 'CIRCAL' onto the diskette quite simply by typing:

DISK! 'PUT CIRCAL'.

The computer then 'puts' the program on the diskette. The inverse of the PUT command is the LOAD command:

DISK! 'LOAD CIRCAL'.

This causes the file to be loaded into the computer. We shall explain the commands of the disk operating system later.

Before the computer can write a file onto the diskette or read one from it, the file name must exist in the directory. Ohio supply various system service routines on diskettes to be able to generate file names in the directory.

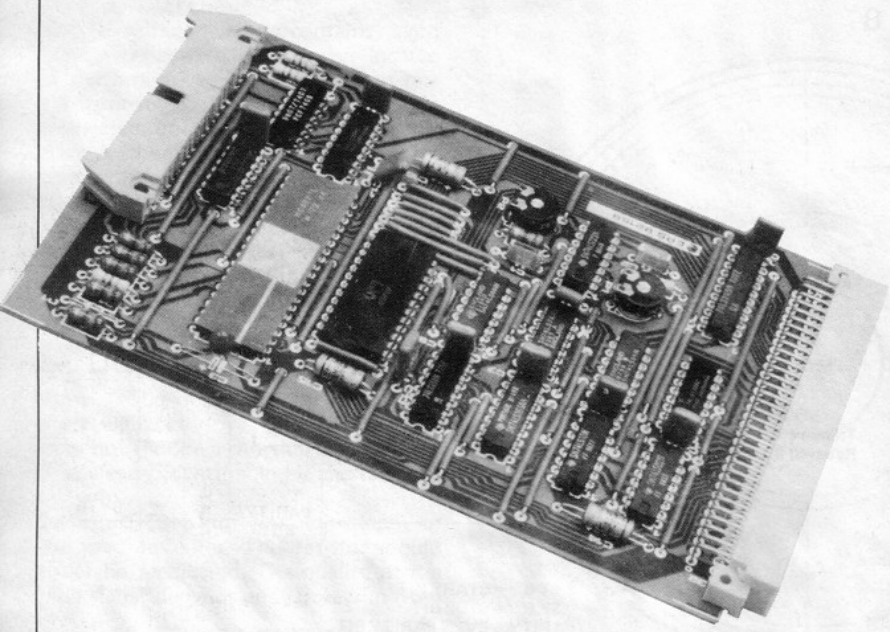
Data pulse to the floppy disk drive

At the end of this article we will demonstrate the electrical signals which the computer sends to the disk drive. Ohio use a very simple transfer format. The data are transferred asynchronously, as with the printer interface of the Junior Computer. Although the printer interface can only handle a maximum of 2400 baud, the floppy disk interface can transfer at 125000 baud. An MC 6850 ACIA, which costs less than 2 pounds, allows this high transfer rate.

The serial data delivered by the asynchronous interface adaptor (ACIA) have the following format:

– One start bit
– Eight data bits
– One even-parity bit
– One stop bit

The even-parity bit is a check bit with which any transfer errors can be traced. This bit is set when the number of set bits in the transferred byte is an even number. Unfortunately the electronic circuitry in the disk drive cannot process the serial signal of the ACIA. For this reason the serial data signal must be converted to a frequency-modulated signal. Figure 8 shows how this conversion takes place. At the start of each data bit, a narrow clock pulse of only a few hundred nanoseconds is generated. If the transmitted bit is a



logic 1, a data pulse 'D' is modulated between two clock pulses 'C'. If the transmitted bit is a logic zero no data pulse 'D' is modulated between two clock pulses 'C'. As can be seen from figure 8, the electronic circuitry of the disk drive is presented with a frequency-modulated voltage for transmitting the data. The time elapsing until a bit has been transmitted is only 8 microseconds. For receiving data from the disk drive the frequency-modulated signal must be converted back to a serial data signal. This task is performed by a data separator which is located in the floppy disk interface.

This brings us to the floppy disk interface itself and we will describe its hardware in detail. The following summary indicates everything that is needed to convert a Junior Computer or any other 6502 computer to a DOS computer:

- At least two dynamic RAM cards are needed (see ELEKTOR, April 1982).

To develop large programs, three RAM cards are required.

- A Junior Computer, consisting of the basic printed circuit board, interface card and a bus PCB with five connectors.
- A floppy disk interface card containing a few TTL ICs, an MC 6850 and an MC 6821.
- One or two (if possible) floppy disk drives which have Shugart-compatible connections:

For example the 5 1/4 inch disk drive from BASF, Shugart, TEAC, etc.
Low-cost, surplus disk drives can also be utilized.

- A power supply unit which delivers the following voltages:

+5 V/5 A
+12 V/2.5 A
+12 V/400 mA
–5 V/400 mA
–12V/400 mA

Hardware of the floppy disk interface

A brief study of the circuit diagram of the floppy disk drive (figure 9) shows that only standard, commercially available components have been utilized. We think we have reason to be pleased with this circuitry: this universal floppy disk interface is the lowest-cost interface available on the market at present. All KIM-1, AIM-65 and SYM owners can upgrade their computers from cassette to floppy disk system. However, before the floppy disk interface can be connected to the computer the user should know how the hardware functions. We shall now turn our attention to these interesting technical details.

Data transfer between computer and floppy disk drive

The principle of data transfer between the computer and floppy disk drive can be described as follows:

- The STEP and the DIR line (outputs)

Via the peripheral interface adapter (PIA) IC5 the read/write head of the disk drive is placed on the desired track. The computer emits stepper-pulses via PB3 which are matched to the electronic circuitry of the drive by driver N18. The read/write head is shifted one step inwards or outwards with each pulse. PB2 of the PIA (IC5) and N19 generate the DIR signal. The logical level on the DIR line determines whether the stepper pulses shift the read/write head outwards from the interior or vice versa.

- The TRO line (input)

The TRO line is an acknowledge line from the drive to the computer. The logic level on this line indicates whether the read/write head is placed over track zero.

- The INDEX line (input)

The Index line is an acknowledge line from the drive to the computer. As explained at the beginning of this article, the index hole on the diskette is a zero mark for a soft-sectored diskette. Whenever the index hole passes a light barrier in the drive a pulse is produced on the Index line.

- The WR.PROT line (input)

The logic level on the WR.PROT line informs the computer whether it is allowed to write on the diskette in the selected drive, or whether the diskette is write-protected. The computer only writes on the diskette when the WR.PROT line is inactive.

- WRITE line (output)

The WRITE line switches the electronic circuitry in the disk drive from the read mode to the write mode. Before this line become active, the computer checks via the WR.PROT line whether the diskette is write-protected. If this is the case, the WRITE line can never become active.

- The SEL1, SEL2, SEL3 and SEL4 lines (outputs)

The computer selects one of four drives via the SEL lines. Normally only SEL1 and SEL2 lines are utilized. Line SEL1 controls drive A and line SEL2 controls drive B. When Ohio software is used a floppy disk drive must always be connected to SEL1.

- The SIDE SEL line (output)

The SIDE SEL line is not used with the Junior Computer and is intended for later extensions. Special drives containing two read/write heads can be controlled via this line. These drives can write on both sides of a diskette and read back the stored information from both sides.

- The WDA (output) and RDA (input) lines

The computer writes the data in serial form into the electronic circuitry of the drive via the WDA line. The computer reads the serial data from the drive via the RDA line. The baud rate on these lines is 125 kilobaud. The data transfer from the computer to the drive can be compared to a simple V24/RS232 serial interface. We became acquainted with this interface in the Junior Computer 3 and 4 books. In that application the data are transferred from the computer to the ELEKTERMINAL or from the ELEKTERMINAL to the computer.
The serial data transmitted by the computer to the drive are written in parallel into the ACIA (IC11) and transmitted serially at the TxD output at a rate of 125 kilobaud.
The serial data from the ACIA cannot be directly written onto the diskette. This requires modulation of the serial data with clock pulses which initiate the start of a data bit, as shown in figure 8. Between two clock pulses, a data pulse is then modulated or not, depending on the logic level of the current data bit.
When the computer reads data from the

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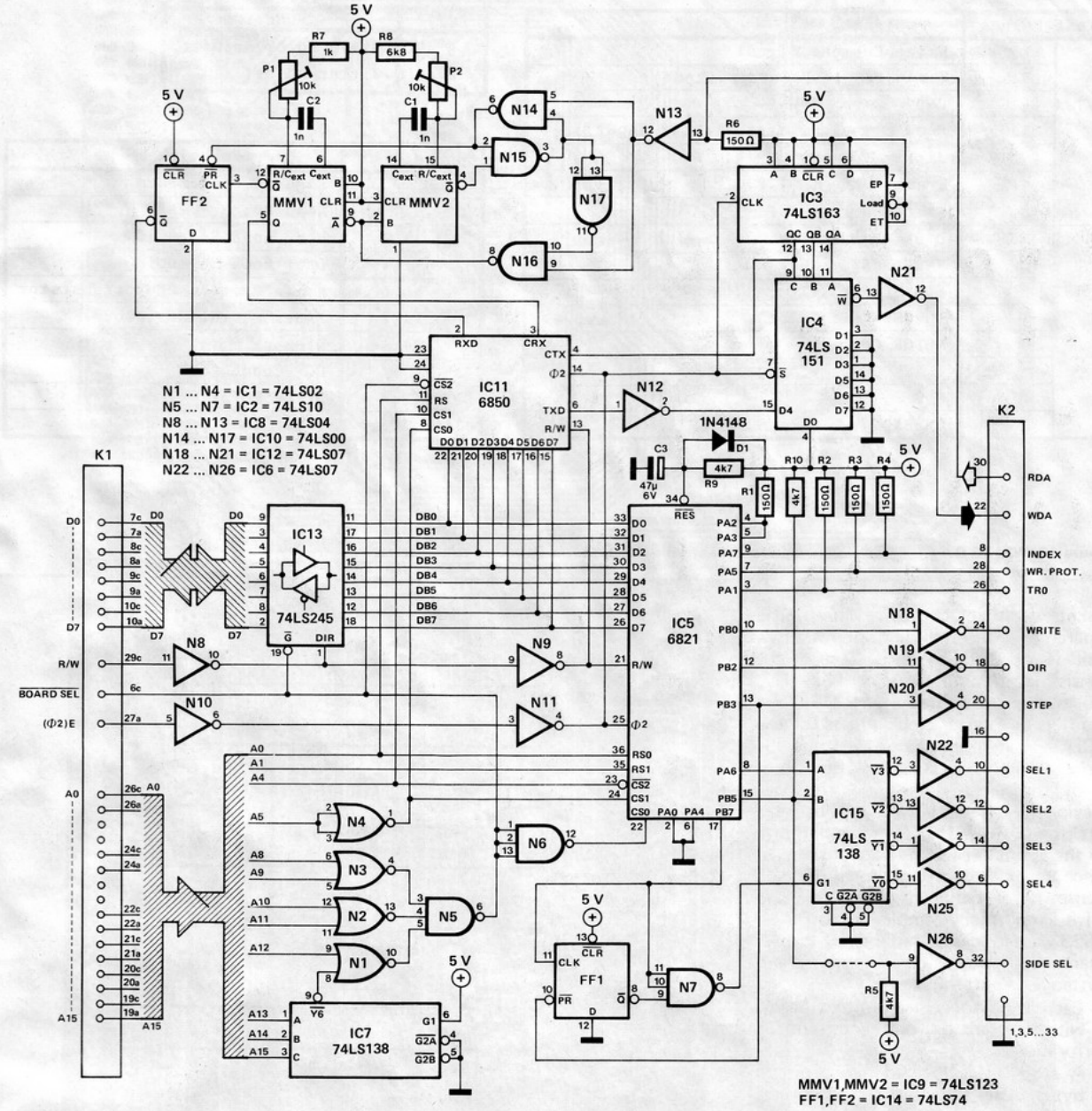

Figure 9. Circuit diagram of the floppy disk interface. Since the data interchange between the computer and drives is controlled by software, one saves the cost of an expensive floppy disk controller. Only standard components are utilised in the circuit.

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Test Points		Signal
TJ1	1,2	Write Current Signal
	3,5	Read Signal (Preamp. Output)
	6	GND
	7,9	Read Signal (Differentiator Input)
	8	Jitter Voltage
	10	Erase Current T.P.
	11,12	Write Current T.P.
TJ2	1	DISK CHANGE FF/
	2	PWRONRESET/
	3	N.O. TRACK ZERO SWITCH
	4	IN USE- FF
	5	MOTOR ON
	6	TRACK 00
	7	GND
	8	INDEX

POTI	FUNCTION
R 47	Drive Motor Adjust
R 69	Jitter Adjust

Connector		Function
J1		Signal - Interface
J2		Read/Write - Head
J3	1,3	Head Load Solenoid
	2,4	Door Lock Solenoid
	5,6	Write Protect Phototransistor
	7,8	Index Phototransistor
	11-18	Stepper Motor
J5		DC- Connector
J6	2,4	Drive Motor
	3,5,6	Track Zero Switch

Figure 10. WRITE DATA ENCODER diagram. Here are the pulses that are emitted to the drive.

diskette the clock pulses must be separated from the data pulses. This task is handled by a data separator consisting of components N13 . . . N17, the two monostables MF1, MF2 and flip-flop FF2. The clock pulses for the ACIA are at output Q of MF1 and the serial V24/RS232 data are at output Q of FF2. The data signal that was previously in serial form can be read out of the ACIA (IC11) in parallel form by the computer via the data bus.

Since the 1/O chip used for serial data transmission between computer and drive is normally employed for V24/RS232 interfaces, a number of known characteristics are found in the transmitted data pattern:

1. Each byte to be transmitted begins with a start bit and ends with a parity bit.
2. A stop bit is located between two bytes. The stop bit is the inverse of the start bit.

Eleven bits are required to transfer one byte:

One start bit, eight data bits, one parity bit and one stop bit. If no data are being transferred, only stop bits are present (logic 1). By using pseudo-FM-encoding, 22 pulses are written onto the diskette during the transmission of one byte (= 8 bits), which only consists of logic ones (= $FF). The reason is that each bit to be transmitted consists of a clock pulse and a data pulse. The clock pulse is always present, whilst the data pulse is only present when a logic one is being transmitted (see figure 8).

This format allows eight pages of 256 bytes each to be stored on one track, i.e. 8-times 256 bytes = 2 kilobytes. Since a few tracks are required for the directory and system program

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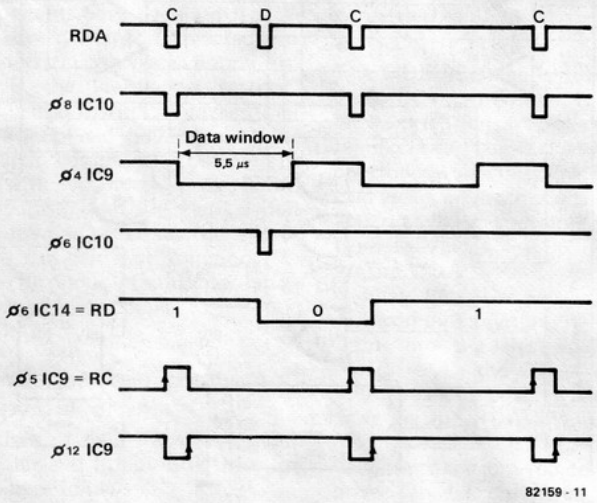

Figure 11. READ DATA SEPARATOR diagram. Here are the pulses arriving from the drive and which are then separated by the data separator.

(= DOS program and BASIC), only 35 tracks available to the programmer on a diskette with a total of 40 tracks. Thus approximately 2 kilobytes times 35 = 70 kilobytes can be stored on a diskette. This is more than adequate for a hobby computer system.

The circuit diagram in detail

The circuit diagram of the floppy disk interface can be subdivided into several groups which we shall now examine:

a. Address decoding and data buffer

The outputs of address decoder IC7 change their states in 8-kilobyte steps. Output Y6 drives IC1 (N1 . . . N4) which decodes the rest of the address lines. If all inputs of gate N5 are logic ones, its output (pin 6) becomes a logic zero. This output always remains a logic zero between addresses $C000 . . . $C0FF. This signal is needed to activate the data bus buffer in IC13. Additionally, the output is wired to pin 6c of bus connector K1.

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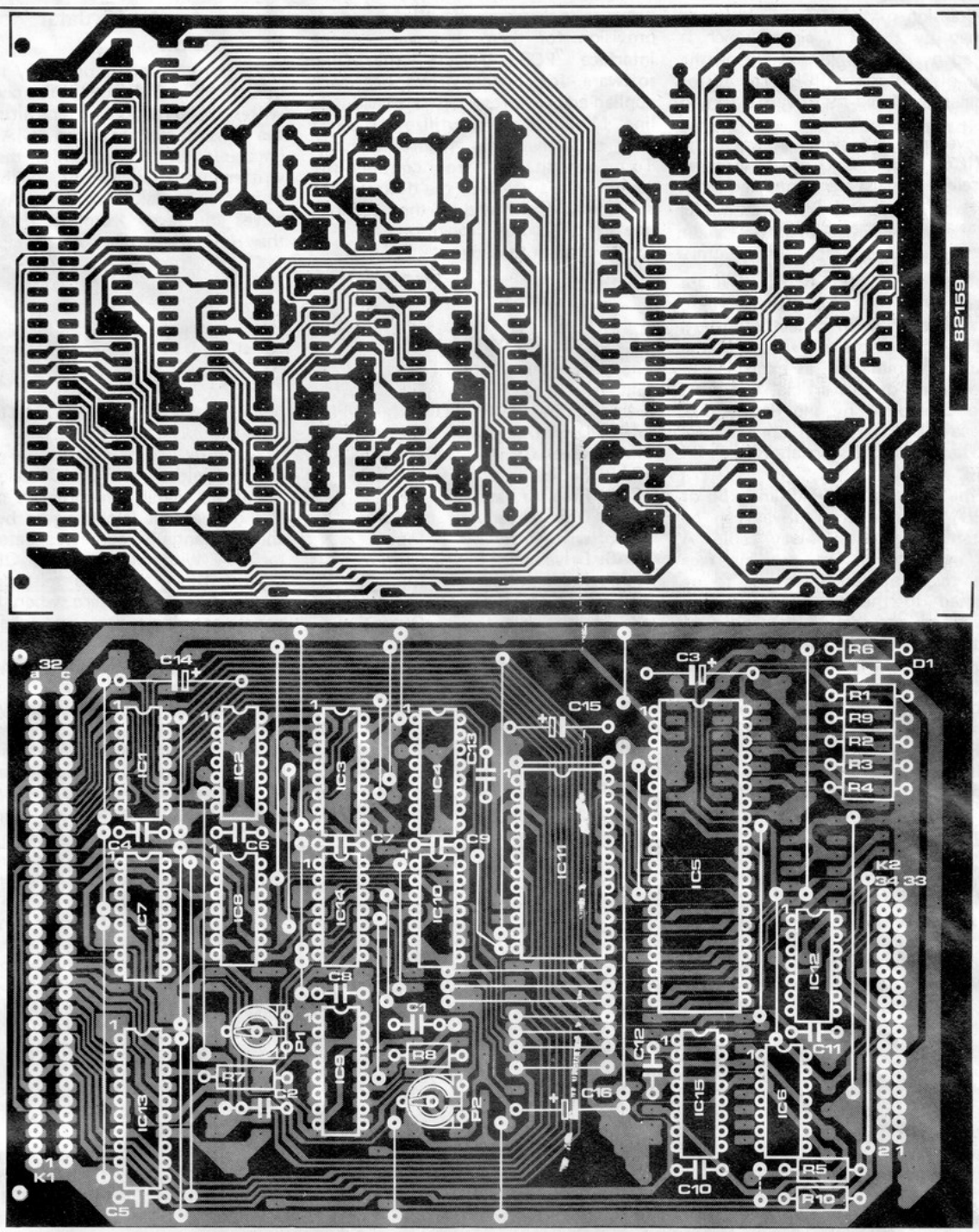


Figure 12. Layout and component overlay of the PCB of the floppy disk interface. Use great care in soldering, because some tracks are very close to each other. Good sockets should be utilised for IC5 and IC11.

Parts list

Resistors:

R1,R2,R3,R4,R6 = 150 Ω
R5,R9,R10 = 4k7
R7 = 1 k
R8 = 6k8
P1,P2 = 10 k trimmer potentiometers

Capacitors:

C1,C2 = 1 n MKT
C3 = 47 µ/6,3 V
C4 . . . C13 = 100 n
C14,C15,C16 = 1 µ/16 V

Semiconductors:

D1 = 1N4148
IC1 = 74LS02
IC2 = 74LS10
IC3 = 74LS163
IC4 = 74LS151
IC5 = 6821
IC6,IC12 = 74LS07
IC7,IC15 = 74LS138
IC8 = 74LS04
IC9 = 74LS123
IC10 = 74LS00
IC11 = 6850
IC13 = 74LS245
IC14 = 74LS74

Additionally:

64-way male connector, rows a and c fitted (Siemens)
Two 34-way female connectors for ribbon cable
Mating plugs for the above for fitting to the PCB, angled
(Molex, Amphenol, ITT-Cannon, etc.)

The direction of the data bus buffer is governed by the R/W signal which is buffered by drivers N8 and N9 on the floppy disk interface PCB. The 02 or E-signal is buffered by drivers N10 and N11.
The inverse C0XX signal activates the PIA (IC5) via the CS0 pin. The other chip select signals are connected with address lines A4 and A5, so that the PIA has a base address of $C000.

b. *Lines between drive and interface*
The outputs to the floppy disk drive are buffered by drivers N18 . . . N26. These drivers have an open collector output. The pull-up resistors are always in the last drive (terminator), as explained at the beginning of this article. The drive is also controlled by the floppy disk interface via drivers with open collectors. The pull-up resistors are R1 . . . R4 and R6.
IC15 multiplexes lines PA6 and PB5 of the PIA, so that four drives can be operated using one 34-way cable. A small modification on the interface allows two doublesided drives to be connected to the computer. This is achieved by connecting the input of N26 to PB5. The connection between PB5 and pin 2 of IC15 must be disconnected in this case.
Multiplexer IC15 is activated via N7. The inputs of N7 are controlled by the head-load output of the PIA (PB7) and the Q-output of FF1. FF1 is set by the step pulse and reset by the leading edge of the head-load pulse. N7 and FF1 are not absolutely necessary. We have made provision for them, however, on the interface PCB because the Ohio software for 8-inch drives has been applied and requires a separate head-load line. Mini-disk drives utilize the select lines to activate the read/write head. To prevent the head from continuously rubbing the surface of the diskette, the select line is activated by the head-load line. This ensures proper treatment of the diskette in the drive.

The port lines of the PIA

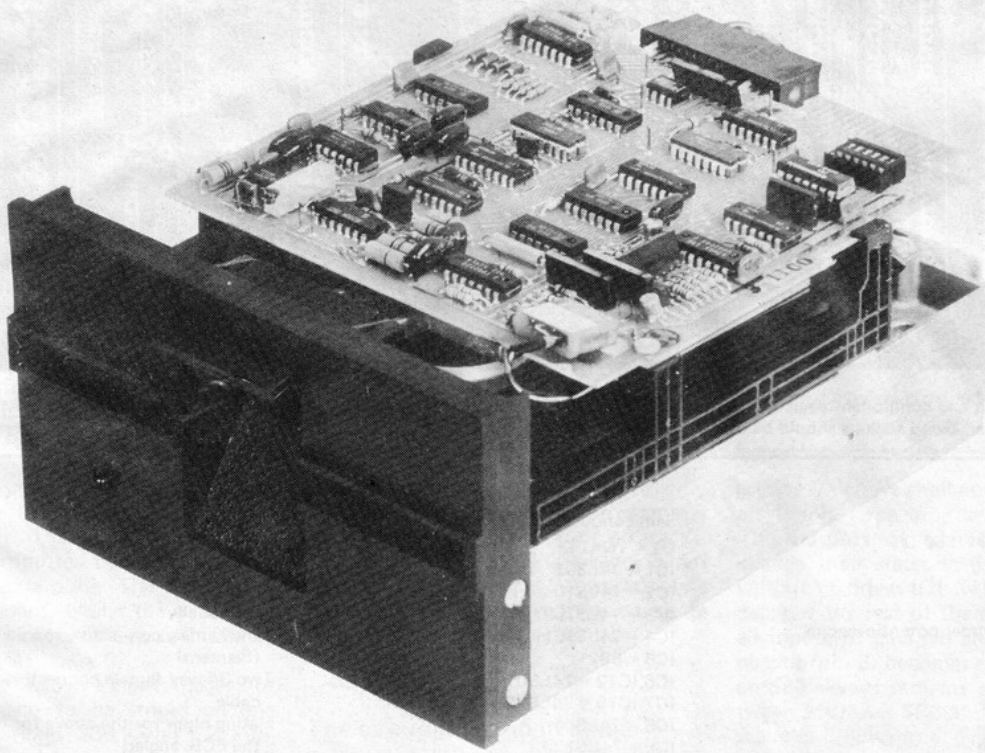
The port lines of the PIA are used as follows:

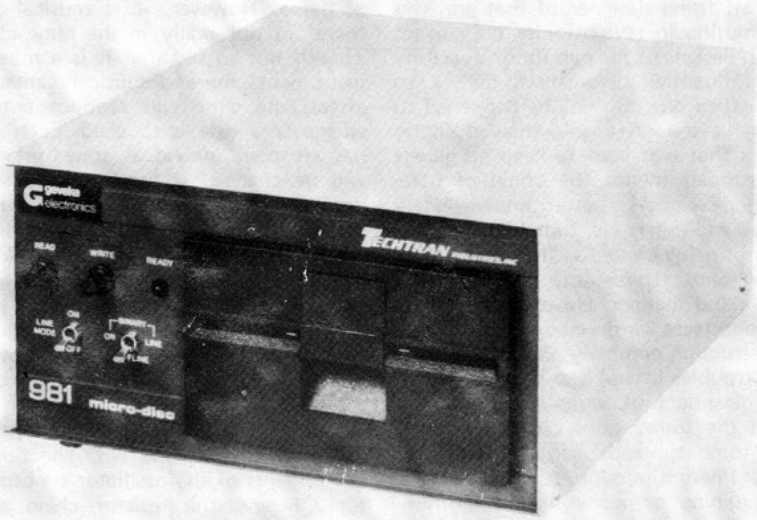
A-side: Address $C000; Disk status Port			
PA0:	Drive 0 ready	Input	
PA1:	Track 0	Input	X
PA2:	Fault	Input	
PA3:	Free for user		
PA4:	Drive 1 ready	Input	X
PA5:	Write protect	Input	X
PA6:	Drive select L	Output	X
PA7:	Index pulse	Input	X
B-side: Address $C002; Disk control Port			
PB0:	Write enable	Output	X
PB1:	Erase enable	Output	
PB2:	Step direction	Output	X
PB3:	Step pulse	Output	X
PB4:	Fault reset	Output	
PB5:	Drive select H	Output	X
PB6:	Low current	Output	
PB7:	Head load	Output	X

All I/O lines are active at logic zero.
'X' = I/O line used.

The electronics for data transmission

Data transmission is primarily handled by the 6850 ACIA (IC11). The computer writes the byte to be transmitted into the transmit register of the ACIA via the data bus. IC11 then shifts the word written in parallel form to the TxD output in serial form. The ACIA receives the serial from the diskette at the RxD input. The clock input for the serial receive signal is designated CRx. If a serial word is read into the ACIA the computer can read it out of the receive register in parallel. We will discuss the register structure of the ACIA in the December issue.
The data to be transmitted are presented to input D4 of data selector IC4 in inverted form (N12). All other data inputs except for D0, are grounded. The select input of IC4 selects the 'E' or 02 signal. Synchronous counter IC3 divides the clock signal by eight and sequentially addresses data selector IC4 with outputs QA, QB, QC. Output 6 of the data selector must always be a logic zero when the 'E' signal is a logic zero and when data input D4 is a logic one. This means that a pulse is always produced at address zero. This pulse is the clock pulse which is repeated every eight microseconds.
When the ACIA (IC11) transmits a logic one, TxD is a logic one and D4 of the data selector (IC4) is a logic zero. The result is as follows:





- During transmission of a logic one, no data pulse appears at the 'W' output of the data selector (IC4).
- During transmission of a logic zero, one data pulse appears between two clock pulses at the 'W' output of the data selector (IC4).
- Each clock or data pulse has a length of only 500 nanoseconds.

The signal at the 'W' output of the data selector forms the coded FM signal which is transmitted via buffer N21 to the floppy disk drive. The WRITE DATA diagram for the write encoder is shown in figure 10.

To be able to read back the data from the diskette, the clock and data pulses must be separated again. After separation, the clock pulses are utilized to shift the serial data pulses into the ACIA at a rate of 125 kilobaud. The separating of clock and data pulses is performed by a data separator consisting of N13, N14 . . . N17, MF1, MF2 and FF2.

Incoming data from the floppy disk drive are inverted by N13. The NAND port N16 is enabled by NAND N17, so that the first clock pulse can trigger both monostables MF1 and MF2. MF1 triggers on the negative edge of the clock pulse whilst MF2 triggers on the positive edge. The Q-output of MF2 should be at logic zero for about 5.5 microseconds, so that N14 is enabled and N16 is disabled. As soon as a data pulse is present between two clock pulses, flip-flop FF2 is set via N14.

The Q-output of monostable MF1 emits a clock pulse of about 1 microsecond to the CRx input of the ACIA. The leading edge of the clock pulse transfers the data bit currently being transmitted to the serial input register of the ACIA. The data bits come from the Q-output of flip-flop FF2. A data pulse on the preset input sets flip-flop FF2. The Q-output then goes to logic zero. The subsequent clock pulse transfers this zero into the ACIA. When MF1 toggles back to the stable state, it clears flip-flop FF2 via the clock input. Figure 11 shows the timing diagram of the READ DATA separator in detail.

Construction and alignment

Construction and alignment of the floppy disk interface are quite simple. All wire links should first be connected on the printed circuit board (figure 12). Since some tracks are very close to each other, soldering requires great care.

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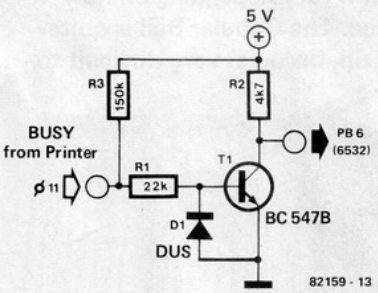


(ϕ11 V24/RS232- connector, Junior Interface Print)

Figure 13. When connecting an EPSON printer with a serial interface, a V24/RS232-to-TTL level converter is required. This little circuit can be wired on the Junior interface PCB in self-supporting fashion. PB5 of the 6532 on the basic PCB of the Junior Computer is used as the BUSY line for the printer.

The resistors, capacitors, diode D1 and the two connectors are then fitted to the board. Trimmer potentiometers P1 and P2 are rotated to their midpoints and soldered into the board. If new ICs are inserted, they can be soldered in directly without sockets. Good sockets should always be employed for the 6850 (IC11) and the 6821 (IC5).

The floppy disk interface should normally work immediately if the two trimmers are set to their midpoints. If, however, fine alignment is still required, the procedure is as follows:

1. Remove the plug from connector K2.
2. Jumper the WDA output to the RDA input on the soldering side of the board using a wire link.
3. Align output Q of monostable MF2 to 5.5 microseconds using an oscilloscope.
4. Monostable MF1 is non-critical and can be aligned to a time of about one microsecond. However, the ACIA and the PIA must then be initialized with a short program. We will go into this in more detail when we discuss the software for the floppy disk interface in the December issue.

EPSON interface

In the Elektor laboratory the Junior Computer operates with an EPSON printer and has therefore been equipped with an interface for the EPSON dot-matrix printer. The following is a description of the necessary interface, for those readers who employ one of these printers.

For connection to the Junior Computer, the EPSON requires a serial interface adapter and not the usual Centronics interface. The commercial price for the serial interface adapter for the EPSON is approximately 23 pounds. The baud rate must be set to 1200 baud by means of the digiswitch provided on the printed circuit board. The ELEKTERMINAL should also run at this rate. The EPSON is connected in parallel to the V24/RS232 output of the ELEKTERMINAL.

The EPSON uses the BUSY line to inform the computer whether data can be transmitted to the printer or not. Since cassette control is no longer necessary on the DOS computer, we have used PB5 of the 6532 on the basic PCB of the Junior Computer as the BUSY input. Relay Re2 on the Junior interface PCB can thus be discarded. The green LED (D5) can continue to be used as a transmit data indicator.

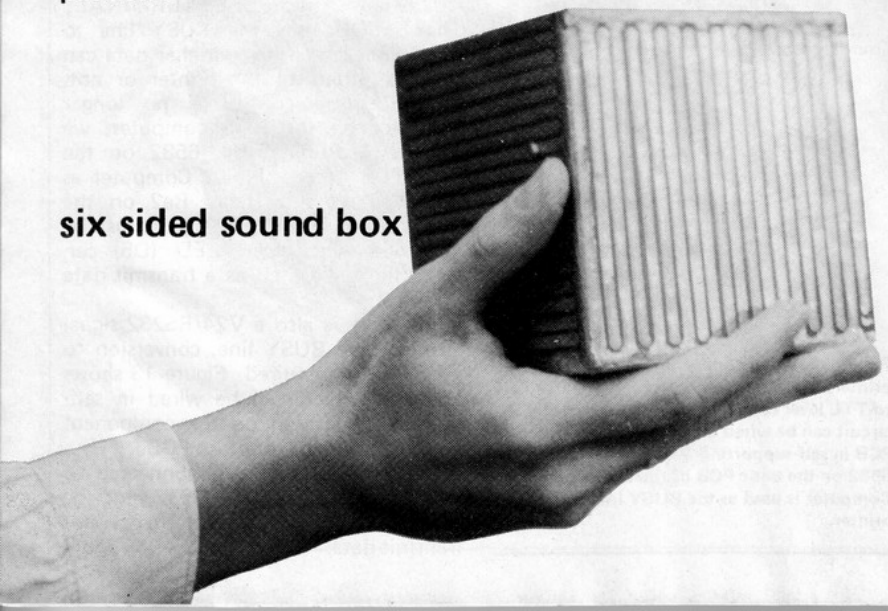
Since there is also a V24/RS232 signal level on the BUSY line, conversion to TTL level is required. Figure 13 shows a circuit which can be wired in self-supporting fashion on the component side of the Junior interface PCB.

If no EPSON printer is connected to the Junior, PB5 of the 6532 must be grounded otherwise the computer cannot transmit data.

K. Siol

cubular bell

Cubes are attractive to the human mind, a fact well proved by the pyramids and the popularity of Rubiks cube. The cube described here contains an electronic 'bell' with a tone that is dependant on how the cube is picked up. Each face of the cube has a touch switch on its surface and contact with one or more of these will cause the cube to produce a sound. However, the sound will vary depending on how many and which of the faces are touched. The Cubular Bell is quite fascinating to all ages and, once picked up, becomes very difficult to put down.



six sided sound box

To answer the first question, what have the pyramids got to do with cubes? It came to pass that El Pharina, a well known tomb designer of that era, was attempting to revolutionise the current tomb designs of the period for a wealthy and influential customer. On the way to the office one morning he happened to stub his toe on a gold inlayed ebony block that was used to keep his garage door open (hence the origin of base-over-apex doors, better known lately as up-and-over). He thus hit upon the idea of using a cube as the basis for his next tomb. It was duly constructed in the grand manner. However, the foundations were contracted to an outside construction company and this is where the troubles began. The dead weight of the gigantic tomb cube was far greater than the foundations could stand and the tomb toppled over at an angle of 45°. Pharina sued of course, putting the mining company out of business. The disaster became known locally as Pharina's yonder ruination of Achmed Mining in the desert, or 'pyramid' for short. All was not lost however, since all the other tomb designers adopted the resultant shape as the state of the art thus creating numerous legends and tall stories, of which, this is one!

History will probably show that Rubik has done more for todays cube than all the other ancients put together and it is entirely possible that our Cubular Bell will not reach the same degree of fame. However, it is musical and therefore not really in the same class. That is not to say that it is a musical instrument, more a musical game. In effect, the cube will produce a tone whenever a side is touched. Each side has its own individual tone but this will be changed if two or more sides are touched at the same time, when picking it up for instance. Replacing the cube on the table will immediately silence it.

This could all work out to be a very complex circuit but a glance at the circuit diagram will show this not to be the case. It will be obvious that the heart of the circuit must be an oscillator and this is formed by the two inverters N7 and N8. The timing components of the oscillator are capacitor C1 and the resistor chain consisting of R7 to R13. Six electronic switches (ES1 to ES6) placed across the resistors are controlled from a touch plate in each face of the cube. If touch switch S1 is bridged by a finger then ES1 will be activated effectively taking R8 out of circuit. The frequency of the oscillator is determined by the total value of the resistors that are in circuit. Which face operates which electronic switch is left up to the constructor, some combinations may be better than others.

The output of the oscillator is fed via a buffer, N9, to our 'audio stage', transistor T1 and the speaker. The type of speaker used is not critical providing it is 8 Ω. The available space will probably be the determining factor!

The one essential point of the cube is that all the faces appear to be identical in order that its orientation remains a mystery. This causes a major problem when a on/off switch is to be fitted. To overcome this we have included an electronic power switch consisting of gates N10 and N11 together with ES7. Briefly, if no touch switch (S1 to S6) is bridged the electronic switch ES7 becomes open circuit thus switching off the oscillator. The use of CMOS ICs ensure that power consumption is kept to a very low level therefore the 9 volt battery should last for quite a time.

Construction

Manufacturing a cube is on a par with making four chair legs independantly — only three legs will ever touch the ground at any one time. Murphy's Law definitely states that the final face of a cube will not fit its alloted space when completing the cube and you can bet your reel of solder on that! For this reason another source of cubes would be a major advantage. Toy shops for the young are a cubic paradise and should provide one or two ideas. Another cube to check out are the 'picture cubes' from that well-

1

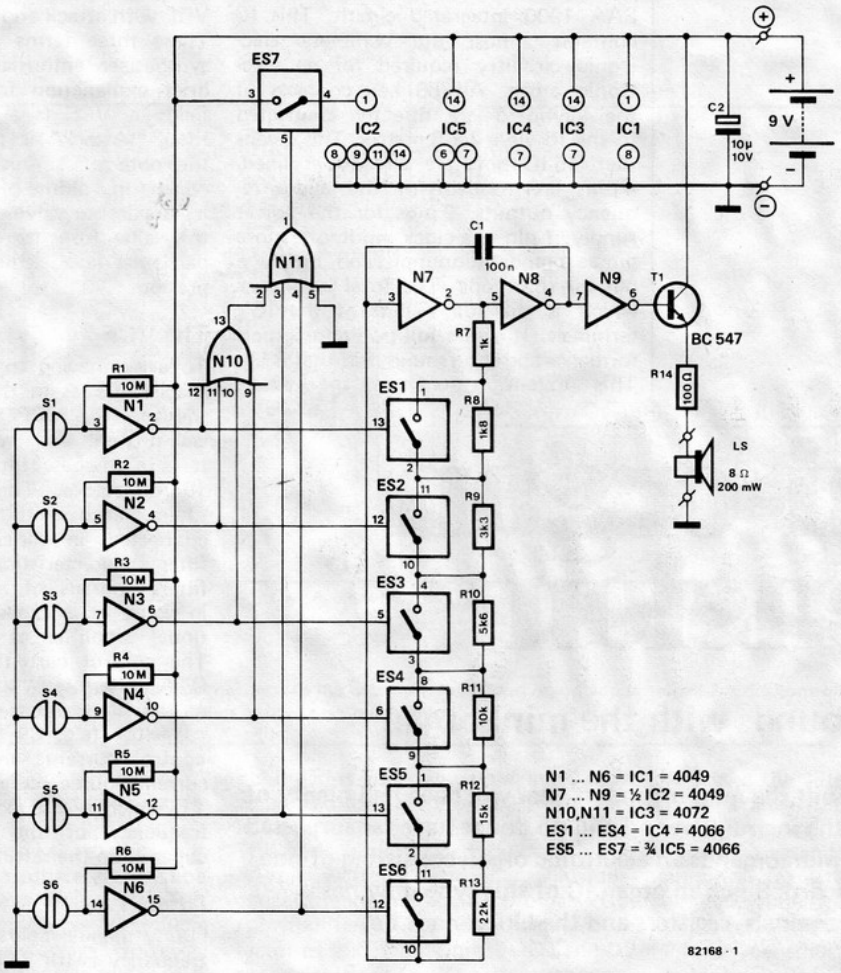


Figure 1. The circuit diagram of the Cubular Bell. The battery will last for quite a while since power consumption is very low. The touch switches can be etched on copper clad board.

known High Street store that don't, in fact, sell footwear. It is well worth shopping around for ideas before aquiring your cube because a good cube is an anonymous cube and very few fit into this category. Bear in mind that each face of the cube must contain a touch switch in one form or another. Figure 2 illustrates how this can be achieved by means of a printed circuit type of switch. If these can be made and fitted onto each face of your selected cube your problems are almost over.

The final problem is that of getting the circuit, the speaker and the battery inside the cube – we have to leave that one with you! Don't forget to make some holes in each face to let the sound out or you will have a mute cube on your hands.

Two points that may make for a more appealing cube. The sensitivity of the touch switches can be increased by raising the values of resistors R1 to R6 to about 22 MΩ. Finally, the tone range can be varied by changing the value of C1 to taste.

Now, if you can get your cube to stand unsupported on one corner, just let us know how . . . .

2

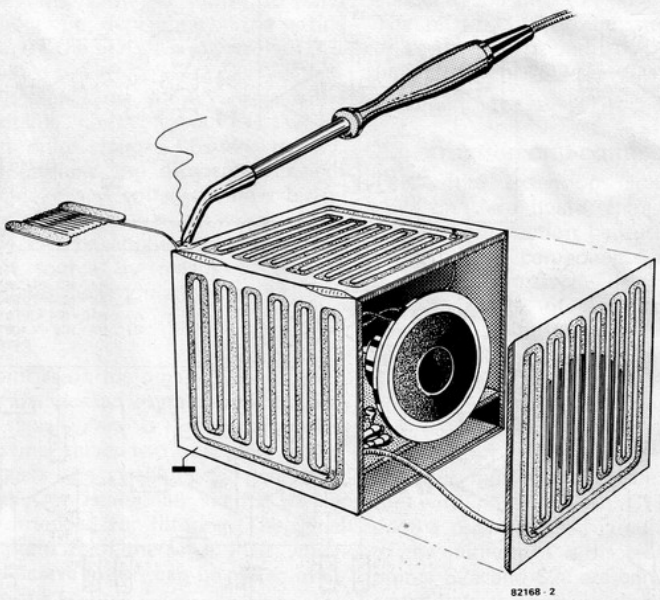


Figure 2. This illustrates one method of making your own cube if a ready made cube is not available. Care is needed if good results are to be achieved.

mini-organ extension

synthesized sounds with the mini-organ

Those of you who built the mini-organ last year will have had plenty of time to practise on the instrument and will no doubt have far surpassed its capabilities. The mini-organ is an electronic organ consisting of one single IC and a keyboard. Since an organ IC of this type only has a limited number of terminals, registers and the like cannot be incorporated.
The extension presented here, however, brings the mini-organ half-way to being a synthesizer.

The heart of the mini-organ is the SAA 1900 integrated circuit. This IC contains almost the complete electronic circuitry required for an electronic organ. All 56 key contacts of the keyboard are directly connected to the IC via a 7 x 8 matrix. This means that 15 IC pins are already assigned. 4 pins are needed for the audio-frequency outputs, 2 pins for the power supply, 1 pin as a clock input, one more pin as a modulation input and, finally, a pin for the mode. The total is 24 pins which is the full extent of the IC's terminals. It offers full polyphonic performance and good sound, but that is all. This extension changes the whole picture. The extension consists of a VCF with attack and decay generator. These three terms will be familiar to synthesizer enthusiasts, but there is a brief explanation for strangers to the field: a VCF is a voltage controlled filter. "Attack" is the phase in which the note of a musical instrument increases in volume or tone from zero to its maximum value. In the decay phase this value drops from its maximum to a particular level, whilst the key remains pressed.

The VCF

To avoid having to employ expensive, special ICs as in the polyphonic synthesizer, the VCF was designed to a well-proven and well-known format. It is a lowpass filter with a skirt of 18 dB/octave. Three active lowpass filters, each with 6 dB/octave, are connected in series to achieve this filter characteristic. Each of these filters consists of an OTA (CA 3080 in figure 1), a capacitor and an operational amplifier as an output buffer. The control current at pin 5 of each OTA determines the basic frequency of the filter, when combined with the capacitor (e.g. C9 in figure 1). These control currents are supplied from a current source, consisting of A11 and T1, which is also controlled. The basic frequency of the entire filter thus depends on the setting of P11.

Attack!

Purely manual adjustment of the basic frequency (with P11) is not sufficient. An organ note filtered in this way still sounds too much like an organ!. What is needed is an attack/decay generator. This type of generator makes the filter

1

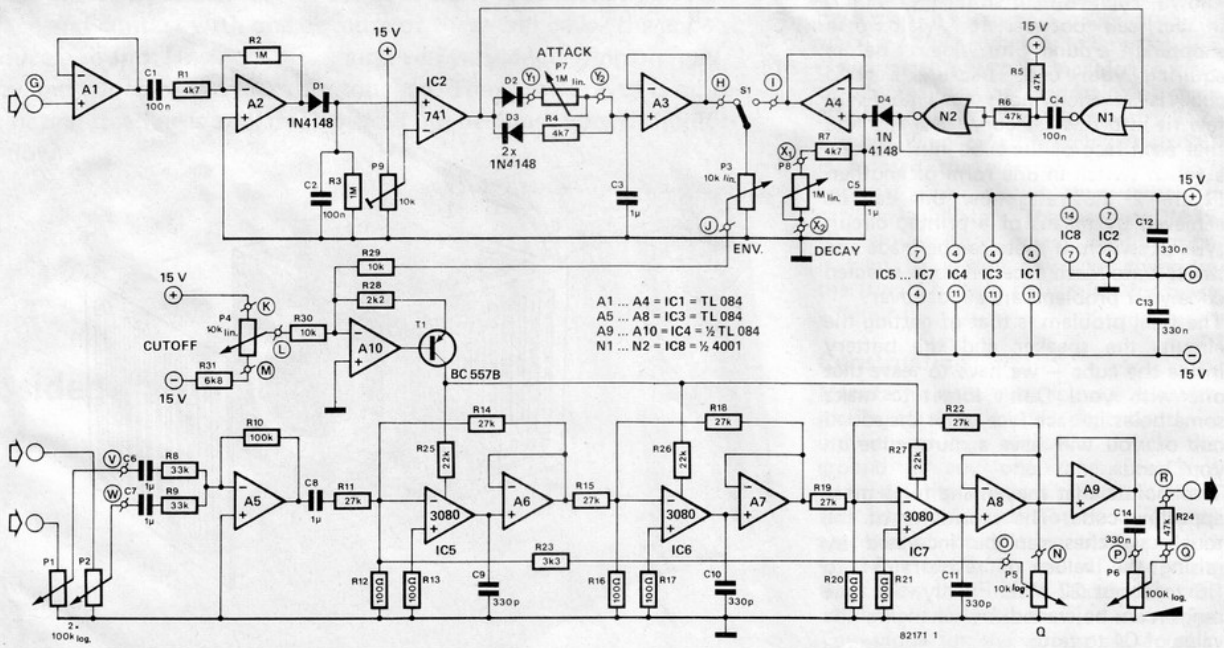


Figure 1. The circuit diagram of the extension. 8 integrated circuits are used to produce an attack/decay generator and a voltage-controlled lowpass filter with a skirt of 18 dB/octave.

2

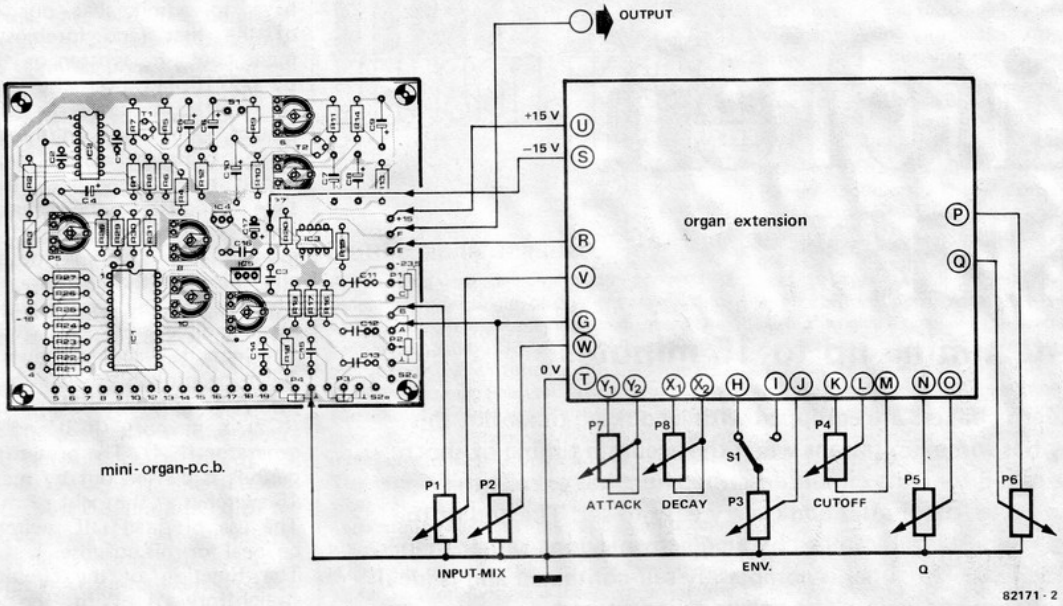


Figure 2. Wiring diagram of the extension. Connections to the organ printed circuit board and terminals for the controls (such as potentiometers and switches) are designated with the same letters as in the circuit diagram.

attack-dependent and opens the way to many possibilities in sound experimentation.

The status of a key, i.e. whether it is pressed or not, unfortunately cannot be indicated by the keys themselves. This would require a second row of contacts and would be very expensive. However, there is another inexpensive method: if the organ is emitting a note, a key must be pressed. It is therefore only necessary to know that a note is present.

This task is performed by A1 . . . A3. A1 picks off the note at a high impedance at terminal A of the organ PCB. A2 amplifies this buffered signal by a factor of 200, i.e. it limits it. D1 and D2 produce a positive DC voltage from the limited square-wave and, based on the level of this voltage, comparator A3 decides whether a note is present or not. D2, P7, C3 and A4 form the attack section. If a key is pressed the voltage at the output of A3 jumps to + and C3 charges up, depending on the setting of P7. At the end of a keystroke C3 is discharged over R4 and D3.

The voltage jump of A3 triggers the monostable consisting of N1 whose output pulse charges C5 very rapidly. P8 determines the discharge time of C5. This decay voltage is now buffered by A5. Either an attack or decay voltage can be applied to the control current source by means of S1. P3 determines the modulation depth.

Parts list

Resistors:
R1,R4,R7 = 4k7
R2,R3 = 1 M
R5,R6,R24 = 47 k
R8,R9 = 33 k
R10 = 100 k
R11,R14,R15,R18,R19,R22 = 27 k
R12,R13,R16,R17,R20,R21 = 100 Ω
R23 = 3ks
R25 . . . R27 = 22 k
R28 = 2k2
R29,R30 = 10 k
R31 = 6k8
P1,P2,P6 = 100-k-pot. log.
P3 . . . P5,P9 = 10-k-pot. lin.
P7,P8 = 1-M-pot. lin.

Capacitors:
C1,C2,C4 = 100 n
C3,C5 . . . C8 = 1 µ foil type
C9 . . . C11 = 330 p
C12 . . . C14 = 330 n

Semiconductors:
D1 . . . D4 = 1N4148
T1 = BC 557B
IC1,IC3,IC4 = TL 084
IC2 = 741
IC5 . . . IC7 = CA 3080
IC8 = 4001

Additionally:
S1 = single-pole changeover switch

Sounds

At point A on the organ PCB, the mini-organ delivers an asymmetrical square-wave signal which is rich in harmonics. This signal serves two purposes: firstly, it triggers the attack/decay generator; secondly, it is applied via P2 as the signal intended for filtering. The signal from point B of the organ PCB, which is one octave lower, can be mixed in by means of P1.

Depending on the Q of the filter adjusted with P5, sounds can be produced which vary from very dull to very bright. Furthermore, P5 can be used to make the filter oscillate. The result is a sinewave oscillator with which widely varying sound effects can be generated via the attack/decay generator and any key of the upper part of the keyboard.

If S2 is in the attack position, P3 and P4 can be adjusted to obtain a sound reminiscent of brass instruments. In the decay position, a piano-like sound can be produced.

Since the output of the filter is fed back to the output stage of the joy-organ, the unfiltered signals can be added to the filtered signals by mixing. The phase shift of the filter produces a phaser-like sound, by eleminating individual, narrow frequency ranges.

Construction and connection

The entire extension circuit can be built on Vero board. It requires some care in construction because 8 ICs and some passive components need to be mounted.

The terminals of each control are identified with letters which also appear in the wiring diagram (figure 2). The power supply for the extension is obtained at the appropriate points on the organ printed circuit board. The only output missing is for the – 15 V and this must therefore be picked off the wire link between C17 and R20 on the organ printed circuit board. S2 of the mini-organ is discarded. Instead, points S2a and S2c are connected with a wire link.

As a general precaution, signal lines should not be too long nor be arranged in the vicinity of the mains transformer.

kitchen timer

accurate timing up to 15 minutes

Most modern cookers are equipped with a cooking timer but this invariably has some limitations when the accurate timing of short periods is called for. The circuit described here has excellent resolution up to 15 minutes and is very easy to set. The end of the preset time period is announced by an electronic gong rather than the usual buzzer. The timer is completely self-contained and is ideal for short cooking periods where accuracy is required.

M.R. Brett

The two most critical parameters in cooking are expertise and timing. We have to admit that our knowledge of the first (and foremost) requirement could be written on the outside of a 2716. However, the second point is a different kettle of fish. If electronics is good at anything at all it surely must be period timing. The circuit here allows four independant time periods to be preprogrammed and selected when required. A further asset of the circuit is the absence of any display that requires watching. The end of the time period is given by an audible 'gong'.

The circuit diagram shown in figure 1 can be broken down into four main parts, the counter (IC1), a comparator (IC2), a memory (IC3) and the sound generator (IC4). The presetting of time periods is carried out by means of the 16 switches at the right of the diagram. The use of quad DIL switches would be ideal for this purpose.

The function of the circuit is fairly straightforward. With the circuit in the quiescient state the $\overline{Q2}$ output of FF2 will be at logic 1 thus the counter IC1 will be inhibited via the reset input. Its outputs will be held low. The A=B output of the compara-

1

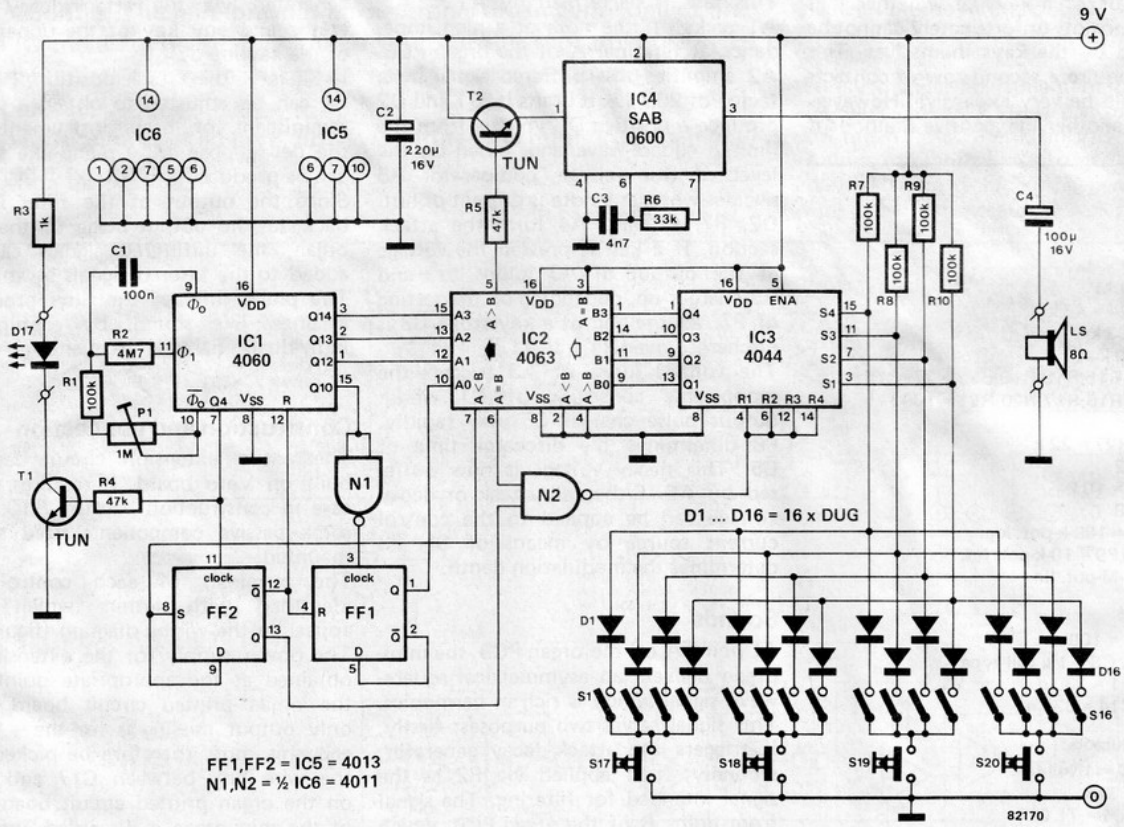


Figure 1. The circuit diagram of the timer consists of four basic parts: the counter IC1, the comparator IC2, the memory IC3 and the sound generator IC4.

tor (IC2) will also be low and the memory (IC3) will receive a reset pulse via the gate N2. The comparator is now ready to accept data relative to the required preset time period. This is preset in BCD format on one set of four switches of S1 to S16. Once selected, the time code is entered into the memory by pressing the relative switch from S17 to S20.

There is now data in the memory and this is presented to the comparator causing the A<B output to change to logic 1. The flipflop FF2 will flip (or is it flop?) which will allow the counter to begin to do its job. This is a very useful IC in that it also includes an oscillator and this is used to provide the clock frequency for the timer. The frequency is determined by the RC network consisting of C1, R1, R2 and preset P1. The latter is included to allow for fine tuning of the oscillator frequency if it is required.

When the reset level is removed from pin 12 of IC1 the counter is enabled and its outputs will count up from 0 at the clock frequency. The Q4 output of the counter is used switch the LED on via transistor T1 as a reminder that the timer is in operation.

The counter will continue doing just that until the A=B output of IC2 goes high, this will occur when the counter output equals the memory. A number of events will now happen. A logic 0 reset pulse will reach IC3 (via N2) and the memory will be cleared. The output of the memory, and therefore the B inputs of the comparator, will all be at logic 0 and, because the count still exists on the A inputs of the comparator, the A>B output will revert to logic 1. This will provide a pulse via T2 to the sound generator, IC4, and the gong will sound to signal the end of the time period.

By this time of course, the A<B output of IC3 will have returned to zero (the A inputs of the comparator are no longer less than the B inputs) allowing FF2 to change state on the next incoming clock pulse from the counter. When this arrives the counter will be reset to zero (the $\overline{Q}$ will go to logic 1) and we are back where we started, waiting for the next time period to be entered via one of the switches S17 to S20.

Although the circuit is rather more complex than the usual 555 based timer circuits it does provide the very useful possibility of a number of preset time periods. The circuit diagram shows four but more are possible if needed. Simply add another switch (S21 for instance) and four more diodes.

The power comsumption of the circuit is low at about 3 mA and the 9 volt battery will last for a good many eggs.

It will be obvious that the applications for this particular timer do not necessarily have to end in the kitchen. It is versatile enough to find a great many uses wherever accurate timing is needed

market

Multi-channel analyser

A multiplexing device which converts a general-purpose single- or dual-channel oscilloscope into an eight-channel instrument has been developed by GSC. The new model 8001 multiplexer, which functions in the same way as a simple logic analyser minus its memory, and allows simultaneous events on different channels to be compared and displayed in direct relationship to one another.

The instrument allows oscilloscope users to view events occurring synchronously or asynchronously, and the user can observe all eight channels at once or one of two 4-channel combinations. Once the overall signal relationships have been observed, the operator can 'zero in' on a single channel by placing the multiplexer in the manual mode and incrementing the display to the desired channel.

Input to the multiplexer is via eight BNC connectors, and the instrument will accept signals of ± 5 V (10 V peak-to-peak) with frequency response which is flat to 12 MHz and 3 dB down at 20 MHz. Input impedance is 1 MΩ. Comprehensive trigger facilities are provided; the signal which is to serve as the trigger is connected to channel 1, and the trigger level can be continuously varied over the ± 5 V range with polarity switchable to positive or negative. Trigger output is a TTL level signal which is internally switch-selectable to 0.01 µs or 1 µs duration, and this is connected to the oscilloscope's external trigger input.

Global Specialties Corporation,
Shire Hill Industrial Estate,
Saffron Walden,
Essex CB11 3AQ
Telephone: 0799.21682

(2510 M)

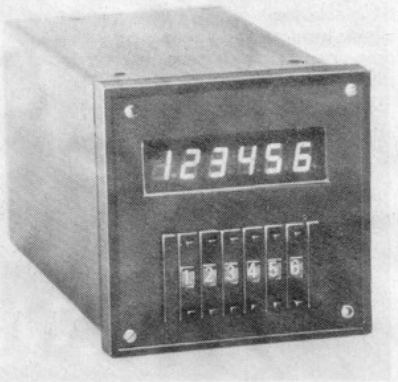
Imperial to metric counter

A big problem for many manufacturers today is the need to sell products in metres, litres or kilograms, using production machinery still fitted with instruments showing yards, gallons, pounds etc.

The solution, from Britec, is both accurate and inexpensive.

The user simply replaces the existing output indicator with one of the new Britec 'pre-scaling' counters. These can be supplied ready-programmed, to give a precise Metric display from an Imperial output, or in a programmable form which the production engineer can adjust on site. By this means, virtually any arbitrary pulse frequency can be 'converted' to give a display in the required units.

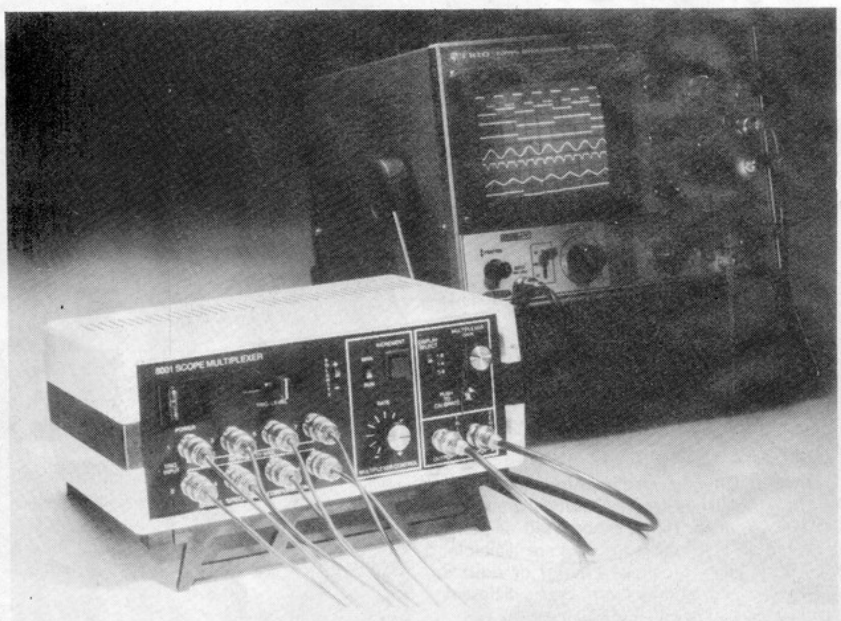
Apart from metric conversions, the Britec 'pre-scaling' counter has many other applications, including for example adjustable batch counting, whereby any required number of pulses can be chosen to advance the counter by one digit.



5 or 6 digit versions are available, with 'up' or 'down' counting; counting speed is up to 25,000 per second; other features include choice of panel or remote re-set, and thumb-wheel batch setting.

Britec Limited,
Unit 17,
Bermondsey Trading Estate,
Rotherhithe New Road,
London SE16 3LL
Telephone: 237.8081

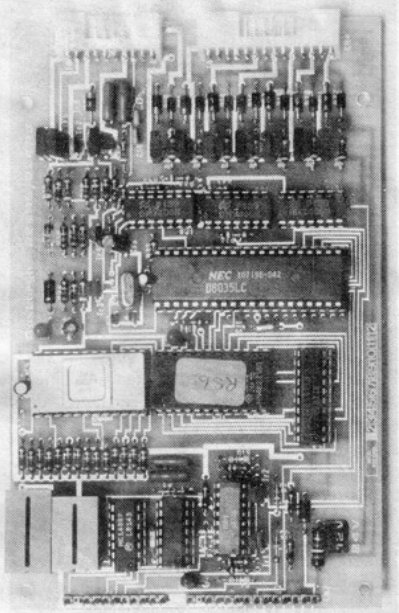
(2506 M)



market

Interface boards

Stotron Ltd., are now able to supply a number of Parallel and Serial Interface Boards which compliment their range of needle printers from Roxburgh Printers Ltd. The compact 12 or 24 V d.c. boards have been introduced to drive 21 and 40 column DP822/824 printers according to the mechanism in use. Both versions offer a full 96 ASCII character set and the Parallel versions have 64 symbols and European characters, and 64 block graphics. This 8 bit parallel version allows inverted and expanded width printing, programmable line feed and variable dot pitch.



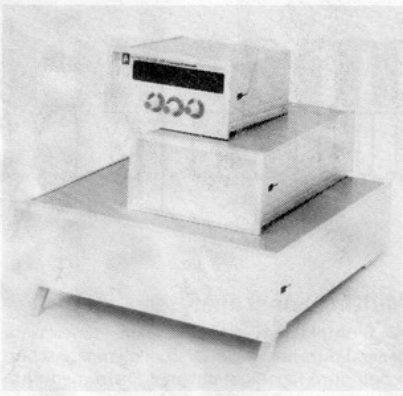
The Serial versions also offer several special symbols, including £ sign, and the character set is stored in a 2716 EPROM to allow alteration if required. These Serial boards also have 20 mA current loop facilities, baud rate (110-4800), parity and stop bit selection.

Stotron Ltd.,
72 Blackheath Road,
London SE10 8DA
Telephone: 01.691.2031

(2504 M)

DIN cases

A range of DIN standard instrument housings are now available from Alusett. Known as the NG72 range, they can be used as panel mounted or desk top. Eight sizes are available, all 72 mm high, single (144 mm) or double (288 mm) width and with four different depths, 150, 200, 250 and 300 mm.



The housings are supplied in kit form including all necessary mounting materials. They are easily assembled with only 10 screws. The housing frame consists of rigid distortion resistant aluminium profiles anodised in natural colours. Top and base cover plates are made of superior quality coated aluminium in a grey-blue colour featuring a fine leather grain surface. Feet can be attached to the base cover plate if the housing is to be used as a free standing or desk top instrument.

Alusett UK Limited,
Whiteshute House,
Whiteshute Lane,
Winchester,
Hampshire SO23 9RA
Telephone: 0962.68673

(2501 M)

Sweep Function Generator

The 12 MHz Sweep Function Generator SFG611 is a high performance instrument offering several versatile facilities which simplify many test measurements in the 0.01 Hz to 12 MHz frequency range. The pushbutton-selected waveforms, sine, square or triangular, are available at levels up to 10 V pk-pk open circuit from 50 Ω. The continuous amplitude control, in conjunction with two fixed attenuators of x0.1 each, give a suitable range of output level control. A d.c. offset facility, adjustable from −5 V through 0 to +5 V, gives a unipolar capability with all combinations of signal and offset free of clipping.

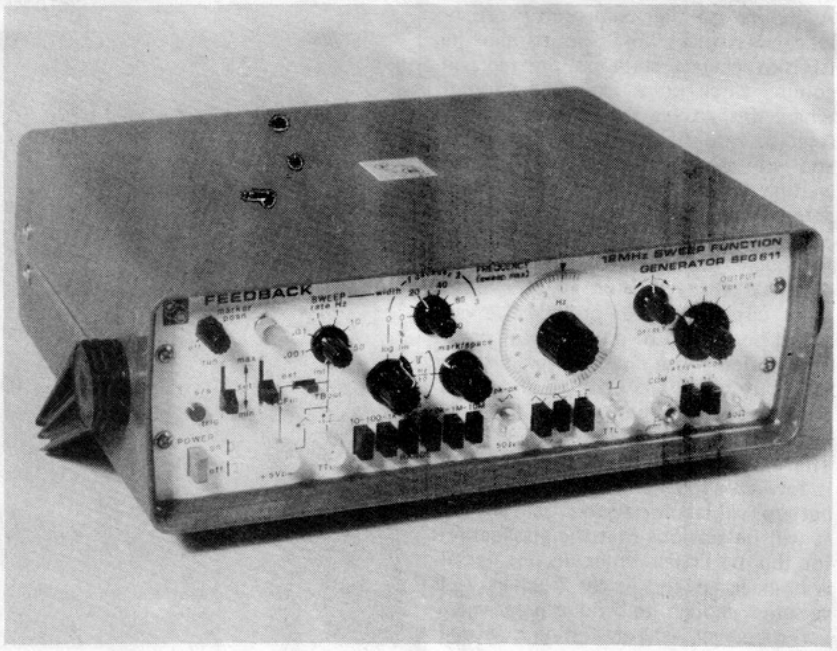
The mark/space ratio of all the waveforms can be varied by a continuous control in conjunction with three switch positions. This offers: a) fixed mark with variable space, continuously adjustable from 1:1 to 1':19; b) continuously adjustable mark/space ratio from 19:1 through 1:1 to 1:19 at a fixed frequency of approximately x0.1 main frequency setting; c) variable mark with fixed space, continuously adjustable from 1:1 to 19:1. The comprehensive sweep facilities can be used in either logarithmic or linear mode, covering the need for overall frequency response or particular narrow-band measurements on 465 kHz or 10.7 MHz. IF circuits, for example.

Internal or external sweep (VCF) can be selected by means of a slide switch. The internal sweep generator is continuously adjustable from 50 Hz to 0.001 Hz by means of a single logarithmic control. A triangular frequency sweep enables both directions of the sweep to be displayed, and an associated auxiliary output is provided for driving the oscilloscope timebase. Also incorporated is a 'single-shot' sweep facility, enabling the SFG 611 to be used with X-Y recorders, the TTL squarewave output then operates as a pen lift control.

Marketing Services Dept.,
Park Road,
Crowborough,
Sussex TN6 2QR
Telephone: 08926.3322

(2503 M)

market



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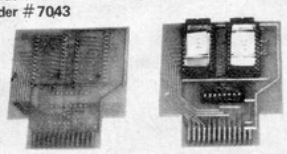

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4042	40p
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